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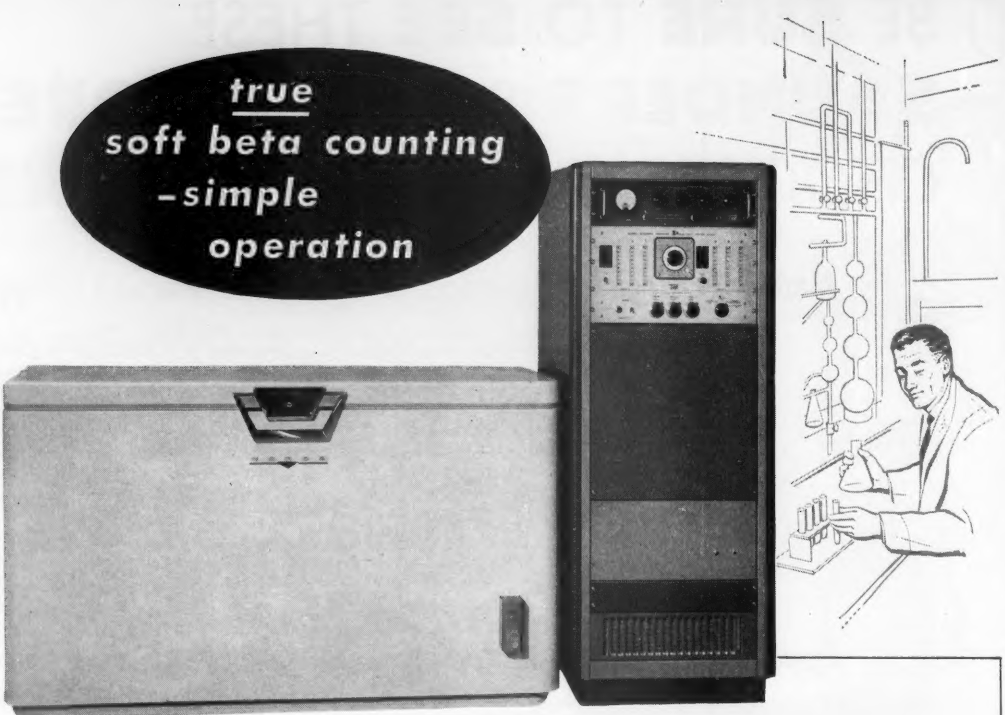

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16 May 1958, Volume 127, Number 3307

SCIENCE

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Journal Publication in Microform

Communication is the blood-stream of science. So emphatically is this the case that it may truthfully be said that science did not become an identifiable human activity until arrangements for communication between scientists were effected. Among these arrangements, publication has always taken a place of principal importance.

Yet publication, so ancillary though so necessary to the progress of science, has continuously presented scientists with one of their principal problems. There is either too little of it, or too much; it is too ubiquitous, or too inaccessible; it is too deficient in detail, or too plethoric. Above all, it suffers from delays and expense which greatly reduce its potential effectiveness. Science has continuously sought for media and methods of publication which would speed up communication, reduce its cost and volume, and—by narrowing a field of interest—both reduce the total quantity of material to be read and at the same time permit greater detail in that which remains to be read.

Microphotography has long seemed to offer possibilities for these purposes. Almost a hundred years ago it was successfully applied by the photographer René-Prudent-Patrice Dagron to the carrier pigeon post which linked Paris to the outside world during the seige of 1870; in similar fashion, it was adapted to the V-mail of the last war. In a notable application, the development of which has not yet expended itself, it was brought to the management of business records in the 1920's, and was thereafter almost immediately extended to lowering the cost and improving the accuracy of the reproduction of scholarly materials.

Microphotography, then, would seem to have demonstrated many of the merits required of a vehicle for scientific communication. Editions can be as small as desired; format can be convenient; publication can ensue as quickly as a legible and edited copy is in hand, and many of the costs associated with letter-press publication are avoided; the enormous compression offered by the miniaturized image is reflected in savings of material, transportation, and storage. The publication of the meteorological data produced by the International Geophysical Year is thus expected to provide subscribers, for \$5000, with 24 trays of 3-by-5-inch cards containing material which, by conventional letter-press methods, would cost more than \$60,000 to produce and would occupy some 750 feet of shelving.

These successes would argue for the possibility of journal publication in microform; yet this has not as yet achieved success. There are a number of reasons for this. Letter-press publication is normal; it conveys prestige; it serves as a vehicle for advertising; but, principally, it can be read with the naked (or nearly naked) eye and requires no elaborate optical mechanisms. And here it may be observed that the greater the reductions used, the more expensive, unportable, and complicated become the ancillary optical apparatus.

Microfilm was borrowed originally from the motion picture industry, and with it all the norms of format, dimension, and allied apparatus. These norms have affected all use of the microforms ever since. It would seem necessary, to achieve better application of microphotography to the communication needs of working scientists, to take a look at the whole process, beginning at the consumer's end. In recent years there has been a great increase in the use of 105-millimeter as contrasted with the original 35-millimeter film, especially for the reproduction of engineering drawings and plans. This size greatly reduces the original, but the material can still be read without apparatus. It may be that we have been asking too much in the way of space-saving.

Several scientific groups are now looking afresh at the possibilities of micro-journal publication. Their experience will be awaited with interest by all who are concerned with the problems of scientific communication.—VERNER CLAPP, *Council on Library Resources, Inc.*

The place of the Particle Accelerator in Basic Research...

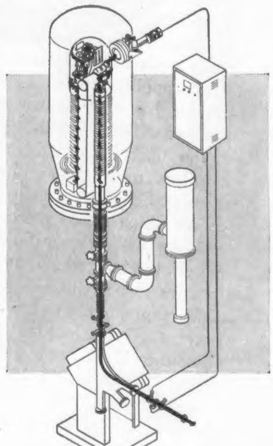
Atomic Displacement by High-energy Particles-VI

Research on the interaction of high-energy particles with atoms in the solid phase has received new impetus with the availability of controlled beams of electrons, positive ions, and monoenergetic neutrons from Van de Graaff accelerators. Investigations in this important field of solid-state physics and chemistry have been the subject of several recent surveys and books. [1, 2, 3.]

Determination of Displacement Threshold

Of great interest has been the determination of the threshold for displacement in semi-conductors, by measurements that can be made with electrons of several hundred Kev. Increasing the energy above the threshold value causes the atom to recoil with sufficiently high kinetic energy to cause further displacements in collisions with neighbouring atoms. Electrons cannot transfer large amounts of energy to these recoil atoms because of the large mass difference, but changes can be effected by heavy particles if they have sufficient kinetic energy. Although high-energy protons and deutrons have been used for solid-state studies, these particles do not provide the best results because they lose energy to the lattice electrons and, at low energies, have a limited range.

Neutrons can be produced with a Van de Graaff accelerator by bombardment of targets such as Li^7 and H^3 with protons or deutrons. The resulting neutron beam is monoenergetic, with a high flux, making it ideal for displacement studies. It does not suffer from the broad energy spectrum of pile-produced neutrons and has relatively low gamma background.



2-Mev positive-ion Van de Graaff with analyzing system.

Thermal Spike

In general the monoenergetic neutrons produced by particle accelerators have energies above the displacement threshold. Their interaction with the atomic nuclei can be described by classical hard-sphere collisions and the subsequent recoil atom energy is sufficient to produce electronic excitation of neighbouring atoms. This phenomenon, originally described in 1923[3], is generally known as a thermal or displacement spike. It is one of the most difficult and yet most interesting phenomena in solid-state radiation reactions.

Seitz, in describing the theory of the high-temperature spike[2], has made an estimate of the volume affected and of the temperature and pressure produced in this region by transfer of incident energy to a lattice atom. Using assumptions deduced from rather meager experimental evidence, it can be shown that the affected volume has a radius approximately ten times the atomic radius. In this volume, the temperature is above the melting points of most solids and the pressure due to the high local temperature is of the order of 10^7 dynes per cm.[2] Although these conditions last for only about 10^{-11} seconds, which is brief in comparison with most chemical reactions, they could be useful for certain selected systems.

One of the exciting possibilities of such local thermal spikes is the use of the extremely high temperatures and pressures for chemical solid-state reactions. Little has been done in this field because of the difficulty of analyzing the results. With the availability of low-energy monoenergetic neutrons from a Van de Graaff, without the complication of Coulomb encounters with the lattice atoms, there appears hope that this promising field will attract more attention.

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4. F. Desauer, Z. Physik, 38, 12, 1923.

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16 May 1958, Volume 127, Number 3307 SCIENCE

Nikola Tesla

Electricity today is generated, transmitted, and converted to mechanical power by means of his inventions.

Kenneth M. Swezey

At the stroke of midnight between the 9th and 10th of July, 1856, a son, Nikola, was born by candlelight to the Rev. Milutin and Djouka Tesla, in the tiny village of Smiljan, Lika, now part of Yugoslavia (Fig. 1). The child's father was pastor of the local Serbian Orthodox church; his mother, though an accomplished needleworker and inventor of household devices, could neither read nor write. From this humble and seemingly unpropitious beginning, Nikola Tesla, driven by some strange, compulsive genius, grew to become a discoverer and inventor whose contributions were, within his lifetime, to change the life and industry of the whole world.

Mention any of today's applications of electricity—and even some not yet fully developed—and the chances are good that Tesla had a hand in their concept and early development. In an incredible flight of achievement, beginning in the early 1880's and racing on for more than two decades, Tesla made basic discoveries and inventions in radio, the wireless control of boats and torpedoes, high-frequency induction heating, electrotherapeutics, gaseous tube and fluorescent lighting, electric clocks, x-ray equipment and techniques, and even rudimentary electric "brains." Before Marconi had flashed his first feeble "S" across the Atlantic, Tesla had already announced plans for a "World Wireless" system which would not only include point-to-point communication but the broadcasting of speech, music, time, and pictures. Tesla's induction motor and related polyphase system for the generation, transmission, and utilization of electric power made possible the first harnessing of Niagara Falls and laid the foundations for the whole modern electric power industry.

Tesla Centennial Celebrations

On 10 July 1956—the 100th anniversary of Nikola Tesla's birth—scientists and engineers from all over the world met in Belgrade, Yugoslavia, to pay homage to the memory of this great pathfinder. Convoked under the auspices of the National Yugoslav Tesla Committee, the Society for the Promotion and Advancement of Science and Technology, "Nikola Tesla," and the Nikola Tesla Museum (Fig. 2) of Belgrade, this celebration marked the beginning of a year of commemorative programs in Europe and America.

Niels Bohr of Denmark, Sir Arthur Fleming of England, Fredrik Dahlgren of Sweden, and Carl C. Chambers of the United States were among the more than a hundred distinguished guests. Richard C. Sogge, delegate of the American Institute of Electrical Engineers, presented a citation to the Tesla Committee from that institute. President Dunsheath of the International Electrotechnical Commission brought word that the commission, at its meeting in Munich, 29 June–7 July, had recognized Tesla's fundamental contributions in the field of electricity by adopting the name "Tesla" for the unit of magnetic flux density in the meter-kilogram-second or Giorgi system.

Although Tesla was born a Serb, he came to America in his late twenties and soon became one of our greatest Americans-by-adoption. Among the American celebrations of his centennial, one of the most important was that of the American Institute of Electrical Engineers, which dedicated to Tesla its Fall General Meeting in Chicago, 1–5 Oct. 1956. Apparatus, photographs, and reminiscences were presented at this meeting, and Samuel G. Hibben, past president of the Illuminating Engineering Society, demonstrated how Tesla's gaseous-tube lighting experiments of the 1890's helped blaze the way for some of the latest developments of today in the field of lighting. Hibben repeated this demonstration on 15 May 1957 at a commemoration sponsored by the Franklin Institute of Philadelphia, where Tesla in 1893 had given one of his most famous lectures. Other memorials were arranged by the Institute of Radio Engineers and the Niagara Falls International Section of the American Institute of Electrical Engineers.

One of the chief objectives of these programs was to sift truth from legend and to set down, evaluate, and publicize some of the great concrete contributions Tesla has made to science and engineering.

Tesla's Greatest Contribution

To those who know of Tesla chiefly through association of his name with the "Tesla coil," it may come as a surprise to learn that his greatest contribution was not this popular device for making high-frequency, high-voltage demonstrations but his discovery of the rotating magnetic field and his brilliant adaptation of it to the induction motor and the polyphase system for the generation, transmission, distribution, and use of

Mr. Swezey, a science and engineering writer who resides at 163 Milton Street, Brooklyn, N.Y., was a close personal friend of Tesla.

electric power. It was this motor and system that was instrumental in changing the era of local electric lighting and a steam engine in every factory to the present age of electric light and power everywhere. Today, practically all the electricity in the world—more than 1500 billion kilowatt-hours in 1957—is generated, transmitted, and turned back into mechanical power by means of these inventions.

The story of Tesla's epoch-making motor and system begins in 1878, during his engineering training at the Polytechnic School at Graz, Austria. Although his father and mother wanted him to become a clergyman, Tesla had begun early to lean toward mathematics and physics. Demonstrations of mechanical and electrical apparatus in the elementary schools in Smiljan and Gospić, and in the higher *Real Gymnasium* in Karlovac, fanned his interest. During convalescence from a nearly fatal attack of cholera, Tesla finally prevailed upon his father to send him to the school at Graz, one of the oldest technical institutions in Europe.

One day Professor Poeschl—Tesla's teacher in theoretical and experimental physics—was demonstrating, before his class, a Gramme direct-current dynamo which had just been received from Paris, running it as a motor. Observing a lively sparking at the commutator and brushes, Tesla ventured to remark that somehow a motor might be invented that would not need brushes (*1*). Such heresy was too much for Poeschl. Likening the idea to that of a perpetual-motion machine, he proceeded to entertain the class and embarrass Tesla by explaining in detail why such a motor would be an impossibility!

At first impressed by Poeschl's arguments, Tesla soon fell back on his own intuition. Through the remaining term he struggled with the problem, designing and redesigning all sorts of direct-current and alternating-current machines in his imagination. In 1880, he transferred to the University of Prague, in Bohemia, and the next year he took a position as chief electrician with the newly formed telephone company in Budapest, Hungary. By this time, the problem of designing a brushless, commutatorless motor had become an obsession. Back in the deeper recesses of his mind Tesla felt that a solution was forming, but he could not give it outward expression.

Late one afternoon in February, 1882, the answer came (*1*). Tesla was walking with a friend, Szigety, through the City Park of Budapest, reciting stanzas from Goethe's *Faust,* which he knew by heart. Suddenly the solution he had been seeking flashed through his mind. He saw clearly an iron rotor spinning rapidly in an electric whirlwind—a rotating magnetic field produced by the interaction of two alternating currents out of step with each other. With a stick, Tesla drew diagrams on the sand, explaining in detail to Szigety the principle of the induction motor Tesla was to patent in America six years later!

From early childhood Tesla could visualize so clearly that he often had difficulty in distinguishing real objects from their counterparts in his imagination. This ability, often annoying and even frightening in ordinary life, Tesla used advantageously in inventing. By means of it he could, for instance, assemble and reassemble mechanical parts, alter sizes, weights, and materials entirely in his mind, and end up by building a model that would generally work exactly as he had conceived it (*2*).

Elated by his discovery in the park, Tesla began to picture in his mind actual machines that would make use of the principle. Within two months he had evolved practically all the types of motors and modifications of a system to run them that later became associated with his name.

Finishing his work with the telephone company, Tesla joined the Continental Edison Company in Paris, where he redesigned dynamos, developed automatic regulators, and also acted as general trouble shooter in power stations throughout France and Germany. While in Strassburg, during the summer of 1883, he experienced the joy of building his first actual induction motor and seeing it run. Unable to interest anyone in Europe in promoting this radical device, he finally accepted the offer of an opportunity to work for Thomas Edison in America.

Tesla arrived in New York in June 1884 with four cents in his pocket, a book of poetry, designs for a flying machine, and a headful of ideas. His first job was with the Edison Machine Works, which built dynamos for the Edison Light Company, where he designed 24 direct-current dynamos with short field pole pieces to replace original machines of the long-pole Edison type. The basic salary was $18 a week, but a bonus of $50,000 on the completion of the task, promised him by the manager, stimulated Tesla to work from 10:30 A.M. until 5:00 the next morning, seven days a week. At the end of a year, the work finished, he asked for his pay—only to find that he had been the butt of a practical joke! Tesla quit promptly (*3*).

Tesla's next backers—having no more use for his newfangled motor and the complex alternating-current system needed to run it than had Edison or the European experts—prevailed upon him to form a company to develop a new system of arc lighting, the type of electric illumination then popular for large public buildings and city streets. But at the end of another year, his work again com-

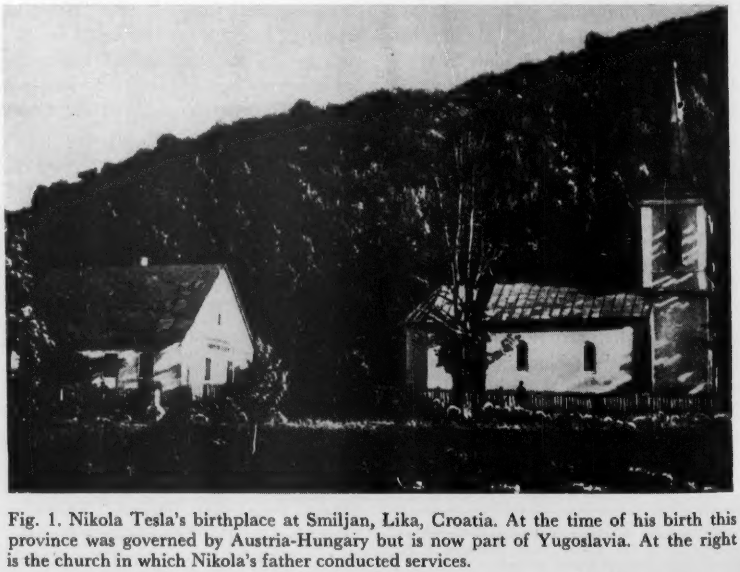

Fig. 1. Nikola Tesla's birthplace at Smiljan, Lika, Croatia. At the time of his birth this province was governed by Austria-Hungary but is now part of Yugoslavia. At the right is the church in which Nikola's father conducted services.

pleted, he found himself richer only by a stock certificate of questionable value.

By April 1887, however, Tesla had secured capital to establish a laboratory in which he could build working models, in practical sizes, of the motors he had previously devised mentally. One by one, he transformed earlier visions into amazing machines of copper and iron—each model working in practice just as he had expected it to.

One of the first eye-witness accounts of the operation of the Tesla motors appeared in a letter from William A. Anthony to Dugald C. Jackson (*4*). Anthony, who had established a course in electrical engineering at Cornell University a few years earlier, had made a series of tests on the Tesla motors as consulting engineer for the Mather Electric Company of Manchester, Connecticut. Jackson was later to become head of the electrical engineering department of Massachusetts Institute of Technology.

The letter reads: "My dear Jackson: I wrote you a while ago that I had seen a system of alternating current motors in N.Y. that promised great things. I was called as an expert and was shown the machines under pledge of secrecy as applications were still in the Patent Office. . . . I have seen such an armature weighing 12 pounds running at 3,000, when *one* of the (ac) circuits was suddenly reversed, reverse its rotation so suddenly that I could hardly see what did it. In all this you understand there is *no* commutator. The armatures have no connection with anything outside. . . .

"It was a wonderful result to me. Of course it means two separate circuits to motor from generator and is not applicable to existing systems. But in the form of motor I first described, there is absolutely nothing like a commutator, the two (ac) chasing each other round the field do it all. There is nothing to wear except the two bearings. . . ."

As Anthony's letter suggests, the sum of Tesla's conception was not merely a new motor that could be operated from an existing system; it was a unique system for the generation, transmission, and utilization of electric power, of which his motor formed but a part. The system started with an alternating-current generator having windings which produced two, three, or more separate alternating currents that followed each other, out of step or phase, as the rotor revolved. By leading these "multiphase" or "polyphase" currents, kept always separate, to windings distributed symmetrically around the stator of a motor, a rotating magnetic field was created in the stator which reproduced exactly the magnetic conditions in the generator.

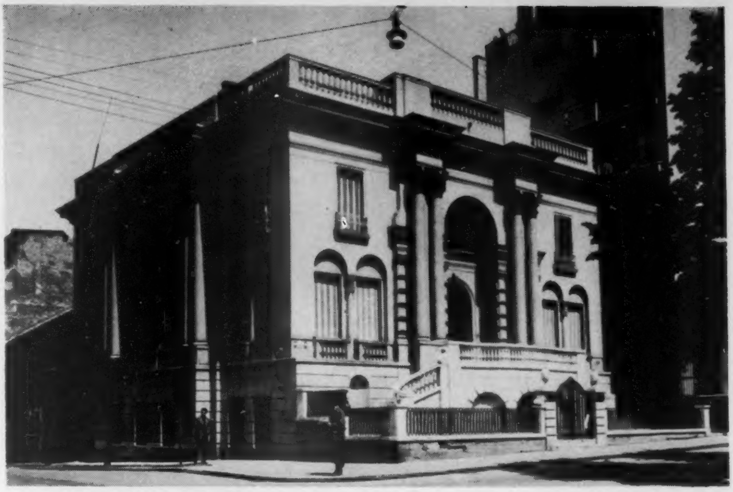

Fig. 2. The Nikola Tesla Museum in Belgrade, where Tesla's personal papers, apparatus, and other belongings are now permanently housed.

Properly designed rotors placed in this field were whirled by it to produce mechanical power. Using an unwound rotor of iron or steel, Tesla obtained a motor which had a low starting torque but which kept in exact step with the rotations of the field, regardless of load; this was the first polyphase synchronous motor. Using a rotor wound with coils of wire closed on themselves, Tesla produced a second type of motor which developed a high torque in starting, built up speed almost to synchronism with the field, and maintained this speed under widely varying loads. As rotation in the latter motor was due to the interaction between the magnetism induced in the rotor coils and the rotating magnetic field which produced it, this motor became known as the polyphase "induction motor."

In October 1887, Tesla began sending applications to the U.S. Patent Office covering a comprehensive system of motors, generators, transformers, and methods—all in an amazing variety of combinations—for the transmission of electric power by the joint use of two or more alternating currents. On 1 May 1888 he was granted his first set of history-making patents.

Fifteen days later, at the urging of Anthony and T. Commerford Martin, Tesla publicly introduced his motors and system in a classic paper, "A new system of alternate current motors and transformers," which he delivered before the American Institute of Electrical Engineers and which was later printed in its *Transactions* (*5*). One of the model motors Tesla demonstrated at this lecture is shown in Fig. 3.

To better appreciate the part these inventions were soon to play in revolutionizing the electrical industry, we must recall the condition of that industry at the time of their introduction. In all the United States there were several thousand central stations operating by means of over twenty different "systems"—combinations of circuits and equipment usually centering around an invention or group of inventions and named after the inventor or manufacturer.

The high-voltage direct-current systems of Charles Brush and others supplied current to arc lamps strung in series for street lighting but could not effectively run lamps or motors. Edison's low-voltage direct-current system lit incandescent lights in densely populated areas in big cities but, because the cost of transmission rose so steeply with distance, could not reach out more than a few blocks from the generating station. By means of transformers which stepped up the voltage for economical transmission and then down again for use, the single-phase alternating-current systems of Westinghouse and Thomson-Houston made incandescent lighting at a distance feasible, but there was no satisfactory alternating-current motor.

In other words, there were many small generating stations, each designed for a specific use, but none able to supply electricity in large amounts for all uses. Also,

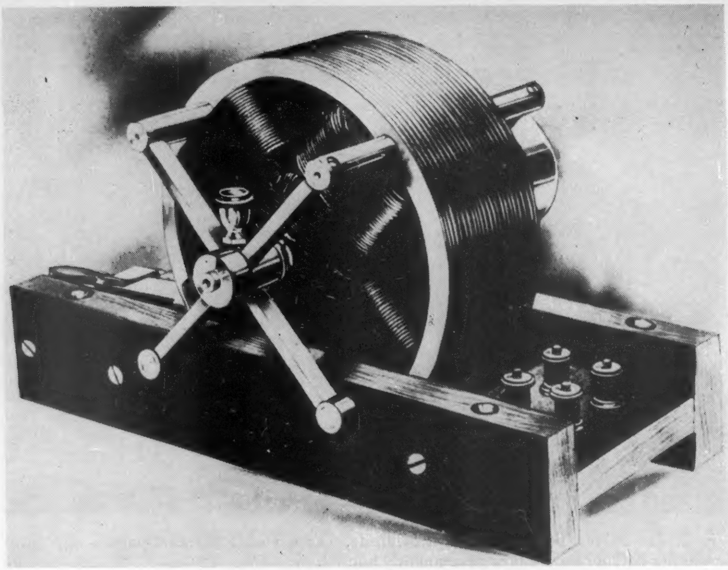

Fig. 3. One of the original induction motors demonstrated by Tesla in his historic lecture before the American Institute of Electrical Engineers at Columbia University, 16 May 1888. This machine developed about ½ horsepower. [Courtesy of the Nikola Tesla Museum, Belgrade]

electricity was used almost exclusively for lighting, difficulties with existing motors and transmission systems making the widespread use of motors impracticable.

George Westinghouse, who had founded his electrical business two years before, largely on the single-phase alternating-current patents of Lucien Gaulard and John Gibbs, pioneer inventors of transformers and alternating-current distribution in Europe, immediately saw in Tesla's motor a means for breaking through this dead end. Within two months after Tesla's lecture before the American Institute of Electrical Engineers, Westinghouse had acquired rights to the Tesla patents and Tesla's personal services to help develop the patents into commercial equipment.

The great hope of Westinghouse was that the Tesla motor could be adapted to existing single-phase circuits, in which most of his company's capital was tied up. At the time, Westinghouse had neither the money nor the interest to try to introduce a radical system which would require completely new generating and transmission equipment.

Tesla helped out by devising several types of "split-phase" motors—induction motors with windings which so divided a single-phase current that it did the work of two. But even these motors—which have since become universally used about the shop and home for performing chores that require fractional horsepower—refused to work efficiently on the 133-cycle current then in use. After several years of failure in trying to adapt the motor to the existing frequency, Westinghouse engineers finally changed the central-station frequency to suit the motor! The frequency they decided on—low enough to run the motor efficiently yet high enough to prevent lights from flickering—was 60 cycles, the frequency which has since become standard for practically all light and power production in America.

Polyphase System Harnesses Niagara Power

The challenge which brought about the widespread introduction of the true polyphase system was the first large-scale harnessing of Niagara Falls. In 1886, a charter had been obtained to utilize about 120,000 horsepower of Niagara's might for purposes of industry. One of the first schemes for accomplishing this involved the formation of an industrial community several hundred yards wide and extending for a mile and a half along the Niagara River. Mills and factories within this area were to be directly connected to 238 water wheels of 500 horsepower each; the water from these would discharge into a tunnel about two and a half miles long, emptying below the falls.

The impracticability of such a scheme soon became evident. For one thing, it would cost too much to build the necessary canals and hydroelectric equipment. For another, how could a city of 5000 population ever hope to attract enough industry to absorb more power than was then used in all the mills and factories in Minneapolis, Holyoke, Lowell, Lawrence, Cohoes, and Lewiston combined? To utilize so much power effectively, a means would have to be found to transmit the power beyond Niagara—possibly even to Buffalo. But by what means?

Hoping to enlist the world's best engineering talent in this quest, the International Niagara Commission, headed by Sir William Thomson (soon to become Lord Kelvin) was established in London in 1890 and authorized to offer $22,000 in prizes for the best ideas for carrying out the undertaking. This commission, which included Coleman Sellers of Philadelphia, E. Mascart of Paris, Theodore Turrettini of Geneva, and W. C. Unwin of London, was probably the first notable international group of scientists organized for industrial purposes. Seventeen projects were submitted by 20 representatives of six countries.

Among these projects were plans for transmitting power from water wheels to mills by means of manila and wire ropes, by water pressure conveyed through pipes to distant turbines, and by compressed air. Of those who advocated transmission by electricity, only two favored use of alternating current. Edison and Kelvin (who were not competing for prizes) advocated the use of direct current, their plan being to connect a number of direct-current dynamos in series to build up a high voltage for transmission and then to distribute this voltage at the receiving end by means of motors also connected in series. Believing that no method of electrical transmission was yet ready for such a great undertaking, George Westinghouse privately recommended that power be generated as compressed air; this would then be piped to Buffalo to run existing steam engines. Having found none of these projects worthy of first prize, the commission was disbanded in February 1891.

The first hint that the Tesla polyphase system might be the answer to this greatest of engineering problems of the day came from Europe in August of that same year. C. E. L. Brown, electrical director of the Maschinenfabrik Oerlikon in Switzerland, and Michael von Dolivo-Dobrowolsky of the Allgemeine Electrizitäts Gesellschaft in Berlin, had been investigating the capabilities of polyphase generators, motors, and transmis-

sion for several years. At the Frankfort Exhibition these engineers demonstrated the results of their labors by lighting 1000 16-candlepower incandescent lamps and running a 100-horsepower motor by means of three-phase alternating current that had been transmitted from a generator in Lauffen, 108 miles away. To do this they sent voltages up to 30,000 and power up to nearly 200 horsepower over three bare copper wires, each only 4 millimeters thick! (*6*).

The second hint came from America. Spurred by the success of the Lauffen-Frankfort transmission, by that of several smaller polyphase installations made by his own engineers, and by the hope of getting the Niagara contract, Westinghouse became enthusiastic about polyphase power and felt that his grand chance to introduce it would be at the 1893 Chicago World's Fair.

By underbidding Edison, Westinghouse won the contract to light this great exposition—the first world's fair to be lit by electricity—and proceeded to do so by means of the Tesla system. Because there were no large polyphase generators yet in existence, he improvised 12 1000-horsepower two-phase generators by coupling 24 500-horsepower single-phase generators in pairs in such a way that their circuits were 90 degrees out of phase. As an extra feature, he also demonstrated the first complete polyphase system ever assembled in units of commercial size. In this, current from a two-phase generator was stepped up by a transformer, sent over a short transmission line, stepped down again by transformers, and used as two-phase current to run induction and synchronous motors and as single-phase current to light lamps and run split-phase motors. To show the complete adaptability of the system, he demonstrated how a rotary converter could change polyphase alternating current to direct current for running a railway motor.

The Lauffen-Frankfort transmission had proved to the scientific advisers of the Niagara project that polyphase power could be sent economically over any distance commercially desirable. The World's Fair exhibit demonstrated further that it could be used to supply all electrical needs. In October 1893—just five years and five months after the issuance of the basic Tesla patents—a contract was signed with the Westinghouse Company to build the first two Niagara generators, of 5000 horsepower each.

In April 1895 the first generator began turning (Fig. 4). In August, electricity was delivered to the first customer—the Pittsburgh Reduction Company, now the Aluminum Company of America. Before the end of 1896, a 22-mile transmission line carried Niagara power to operate the lights and streetcars of Buffalo.

Almost overnight, the Niagara plant became the electrical wonder of the world. Soon, seven more generators were ordered from Westinghouse to complete Power House Number One. Original plans for transmitting power from Power House Number Two by means of compressed air were abandoned, and 11 more generators to complement this station were ordered from the General Electric Company. In 1896, the New York Edison Company began to expand the range and usefulness of its direct-current system by means of polyphase transmission between stations, and several years later it adopted the Tesla system for all new stations. By the time the Niagara plant was completed, in 1903, all new generating stations in the United States were being founded around the Tesla inventions (Fig. 5). The age of modern electric power had begun.

Besides lighting homes and streets, running trolley cars, and replacing steam

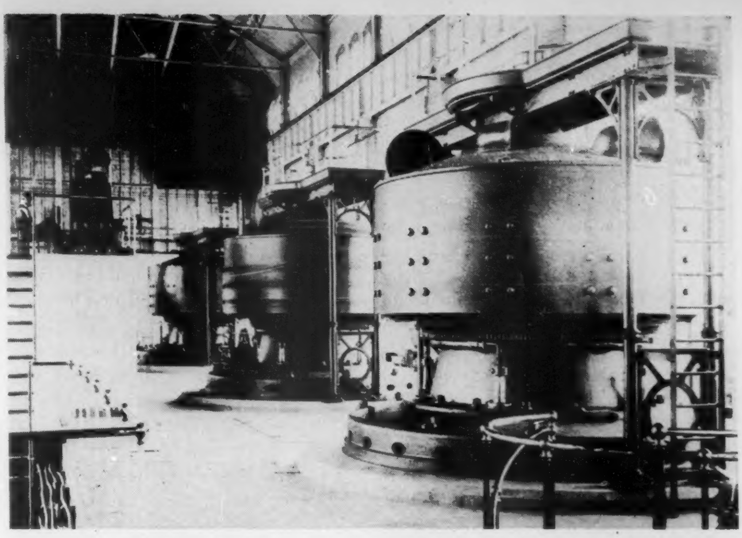

Fig. 4. The first three 5000-horsepower generators of the Tesla polyphase system installed at Niagara Falls in 1895 and 1896. Later rebuilt to operate at higher voltage and as three-phase instead of two-phase generators, they are still in operation and produce the same kind of current as atomic-energy electric plants of today.

Fig. 5. A recent photograph of the nameplate of one of the earliest generators at the first great Niagara Falls plant. Nine of Tesla's patents are listed. [Courtesy of the Niagara Mohawk Power Corp.]

engines in mills and factories, the new power from Niagara, provided cheaply in previously unheard-of quantities, helped inaugurate great new electrometallurgical and electrochemical industries. Ten kilowatt-hours of electricity, for example, are required in the making of every pound of aluminum. Before power from Niagara was available, Charles Martin Hall could not get enough electricity cheaply enough to make his aluminum process a commercial success. Using an electric furnace operated by a steam-driven generator, E. G. Acheson had failed in his attempt to produce carborundum. As the second customer for Niagara power, he was enabled to found a giant artificial abrasives industry. Willson, the inventor of calcium carbide, had been working at Spray, North Carolina, with a 200-horsepower furnace. Furnaces of 20,000 horsepower each were later set up at Niagara. Within less than a generation, the largest electrochemical community in the world had been built up around Niagara power.

Tesla Patents Sustained by Courts

The moment Tesla's induction motor and polyphase system showed signs of success, the usual costly and bitter patent litigation, cries of anticipation by others, and attempts at patent evasion began. These lasted so long and became so involved that many engineers never knew the outcome, with the result that rumors still persist that Tesla lost out to others in this important field.

Galileo Ferraris of Turin, Italy, for example, had in 1888 (two months before the issuance of Tesla's first polyphase patents, but six months after his application) published a paper entitled "Electrodynamic rotations produced by means of alternate currents." This concerned laboratory experiments he had conducted in 1885 but had not publicly exhibited until three years later. In these, Ferraris had caused a copper cylinder to revolve in a rotating magnetic field produced by two alternating currents out of phase with each other. The two currents were obtained from a single-phase circuit by bringing out two branches and inserting a large inductance in series with one and a noninductive resistance in series with the other.

Although the principle of this device was similar to that of Tesla's split-phase motor, Ferraris had considered his contrivance merely a scientific toy which was too inefficient ever to be practical as a motor. He did not attempt to patent the idea, and later he graciously admitted that Tesla had independently conceived the idea of the rotating magnetic field and had developed from it a motor that far surpassed in usefulness anything he had personally believed possible. He further gave Tesla complete credit for the conception and invention of the polyphase system itself—a system which Ferraris had thought impractical because of the additional wiring required.

First reports to America on the Lauffen-to-Frankfort transmission gave credit for the three-phase system to Dolivo-Dobrowolsky, who had designed the motors used. C. E. L. Brown, originator of the project and designer of the generator, quickly explained, however, that this transmission was not a test of three-phase transmission but of high-voltage transmission; that "the 3-phase current as applied at Frankfort is due to the labors of Mr. Tesla, and will be found clearly specified in his patents" (7).

Walter Baily, Marcel Deprez, and Charles S. Bradley were among other inventors claimed by rival manufacturers to have anticipated Tesla. In an attempt to evade the Tesla patents, Steinmetz helped create for the General Electric Company what was called the "monocyclic" system. For electric lighting, this system supplied single-phase alternating current by means of two wires; where motors were to be run, a third wire carried another alternating current which operated momentarily to give the motors a start. Holding this system to be an infringement, Westinghouse prepared to sue its bigger rival. In 1896, however, General Electric settled the issue of giving Westinghouse rights to valuable Edison, Van Depoele, and other patents in exchange for the use of the Tesla patents.

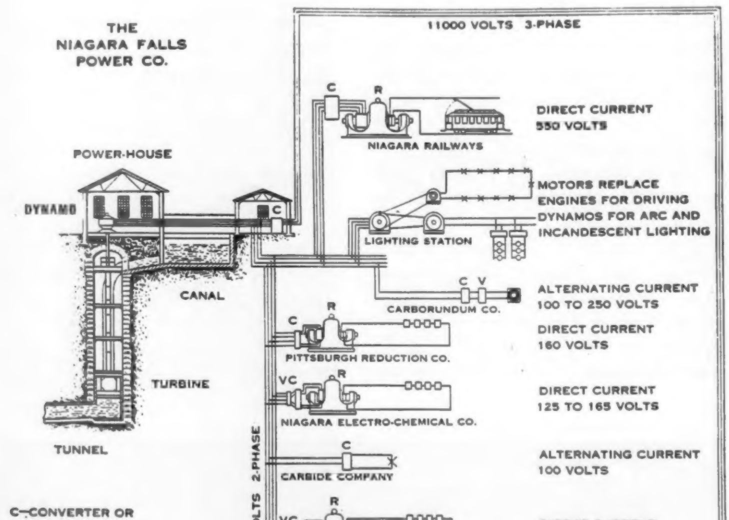

Fig. 6. Diagram of some of the circuits of the first Niagara Falls plant, as of 1897, showing the versatility of the Tesla polyphase system. Originating as two-phase alternating current at 2200 volts, the electricity was easily stepped up or down in voltage and changed to single-phase or three-phase alternating current, or even to direct current, to suit the individual needs of customers. [Charles F. Scott]

The monocyclic system was forthwith abandoned, and so the issue never went to trial.

Had the case been tried, however, the promoters of this unbalanced polyphase system would undoubtedly have lost, as did all the other contenders in a long series of suits which extended over many years. Not only the polyphase induction motor but the split-phase induction motor, the polyphase synchronous motor, and the polyphase system for the transmission and distribution of electric power were all held to be covered by the Tesla patents.

In 1900 Judge Townsend of the U.S. Circuit Court for the District of Connecticut concluded a sweeping decision with these words: "The search lights shed by defendant's exhibits upon the history of this art only serve to illumine the inventive conception of Tesla. . . . It was he who first showed how to transform the toy of Arago (*8*) into an engine of power; the 'laboratory experiment' of Baily into a practically successful motor; the indicator into a driver; he first conceived the idea that the very impediments of reversal in direction, the contradictions of alternations might be transformed into power-producing rotations, a whirling field of force. What others looked upon only as invincible barriers, impassable currents and contradictory forces, he seized, and by harmonizing their directions utilized in practical motors in distant cities the power of Niagara."

Advantages of Polyphase Power

The polyphase induction motor, so beautiful in its basic principle and so simple in its mechanical construction, early proved itself to be not merely a new type of motor but one superior in all ways to the direct-current motor for any use requiring constant speed and considerable power. Its insulation and windings were simpler; there were no brushes and commutator to wear; and it could be designed for greater efficiency. As a result, the polyphase induction motor was cheaper to build and operate, was more rugged, and could be designed in larger sizes and for much higher voltages. It soon earned the title of the "workhorse of industry."

At first the induction motor was regarded as Tesla's great achievement, and the polyphase system was thought of by many engineers as merely a more complex generating arrangement necessary to run the motor. The Niagara plant helped prove, however, that the Tesla polyphase system itself was even more important than the motor it ran. It constituted the first practical means by which electricity of a single kind could be generated in great blocks in one place, transmitted economically over long distances, and used, for any purpose whatever, at another place. So far it has been the last practical means of accomplishing these results, for no substitute that can even approach it in economy and versatility has ever been found.

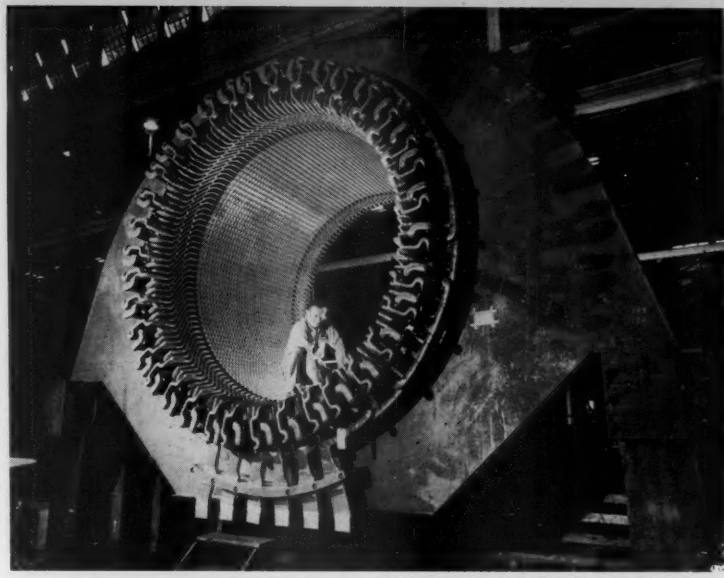

Fig. 7. Today, single and polyphase induction motors and polyphase synchronous motors, all originally covered by Tesla's patents, are built in sizes ranging from fractional horsepower to the 83,000-horsepower giants constructed several years ago to power the wind tunnels of the Arnold Engineering Development Center at Tullahoma, Tennessee. Shown here is the 72-ton stator of one of these machines. [Courtesy of Westinghouse Electric Corp.]

Some idea of the versatility of the polyphase system is suggested by a diagram (Fig. 6) made by Charles F. Scott in 1897, which shows a few of the uses of Niagara power only two years after such power first became available (*9*). Electricity was generated as two-phase alternating current at 2200 volts. It was distributed locally in this form to run induction motors and to turn rotary converters which changed the two-phase alternating current into direct current for supplying streetcars and electrochemical processes. Branches of single-phase current were taken off for incandescent lighting. By means of a transformer invented by Scott, the two-phase current was changed to three-phase current at 11,000 volts for economical transmission to Buffalo. According to Harold W. Buck, who was chief electrical engineer of the Niagara Falls Power Company from 1900 to 1907, to have accomplished the same end results with the direct current suggested by Kelvin and Edison would have required "a radiating copper mine running out from Niagara Falls which would have wrecked the enterprise in the first year of its existence" (*10*).

Progress in electric power development since the adoption of the Tesla inventions has been a matter chiefly of technical refinement and enormous expansion. As late as 1902, the 80,000 kilowatts turned out by the 21 5000-horsepower generators at Niagara equaled the electrical output of 31 states and the territories of Arizona and Oklahoma combined. Today, electric utilities of the United States have a capacity for generating more than 128 million kilowatts, with industry turning out some 17 million kilowatts more. Each of the giant generators whirled by water power at the Grand Coulee Dam now produces more electricity than the entire original Niagara plant (which, incidentally, is still running strong!), and steam-driven generators with a rating of 450,000 kilowatts are now being planned. Because three-phase motors and generators can be designed for about 50-percent greater

output than two-phase machines, on a given frame, and because three-phase current can be sent over three wires with a saving of about 25 percent in copper for a given power, this type of polyphase current is now almost universally used.

Polyphase induction and synchronous motors have been stepped up in size from the ½-horsepower model shown by Tesla in 1888 to 83,000-horsepower mammoths (Fig. 7) used to speed air through the great wind tunnel of the Arnold Engineering Development Center near Tullahoma, Tennessee—the most powerful wind tunnel in the world. Transmission voltages have risen from the 11,000 volts of the original Niagara–Buffalo line to as much as 330,000 volts, and experiments are now being conducted with 500,000-volt lines. "Electric service," which before the introduction of the polyphase system meant arc lights in streets and incandescent lamps in homes and business establishments in thickly populated areas of big cities, now means electric light and power for all purposes in 98 percent of all buildings of America. In addition to lighting, electricity now runs 97 million radios, 39 million television sets, and 100 million miscellaneous appliances, ranging from toasters and percolators to washing machines and air conditioners. Within 25 years, the demand for electricity in the United States is expected to quadruple.

One new use for electricity, completely unforeseen at the turn of the century, is in the separating and making of materials for atomic- and nuclear-energy programs. Plants of the Atomic Energy Commission at Oak Ridge, Tennessee, and Paducah, Kentucky, now require a total of twice as much electricity (generated and transmitted as polyphase current by plants of the Tennessee Valley Authority) as the city of New York. Our Atomic Energy Commission program uses, altogether, more than 60 billion kilowatt-hours of electricity a year, or about 10 percent of all the electricity used in this country.

Fig. 8. Nikola Tesla holding a gas-filled, phosphor-coated, wireless light-bulb which he developed in the 1890's to replace the incandescent lamp, which he considered inefficient. This light-bulb, made nearly half a century before fluorescent lights became commercially available, may still provide some ideas for those who will devise the lighting methods of the future.

However, the total contribution of Tesla's induction motor and his polyphase system for the universal distribution of electric power, encompasses much more than the tremendous growth of the electrical industry which these inventions made possible. To properly evaluate it, we must consider the vast revolution in industry, economy, and everyday living which plentiful electric power, available everywhere, has been instrumental in bringing about.

Tesla Explores High Frequencies

Tesla, elated by his success in creating the induction motor and the first system by which large quantities of electricity could be sent over long distances, found it hard to settle down to a job of working out mere technical improvements on these discoveries, even though he had been given a huge salary by Westinghouse Electric Company and a part interest in the company as an inducement. A year's experience at Westinghouse's East Pittsburgh plant convinced him that his inspiration worked best when he worked untrammeled and alone. In 1889, Tesla returned to his own laboratory in New York to begin investigations on several completely new frontiers of electricity and mechanics.

Most spectacular of these were his researches in high-frequency phenomena; these brought him world fame and contributed enormously to such fields as radio, diathermy, induction heating, gaseous tube lighting, and radio-guided weapons.

Tesla's first interest in currents of high frequency was the result of his ambition to develop an electric light which would be more efficient and adaptable than the newly developed incandescent lamp of Edison, Swan, and others. Hertz had recently demonstrated that high-frequency oscillations could be produced by a condenser discharge. Crookes had produced fascinating glow effects by passing high voltages from a spark coil through glass tubes filled with various gases at low pressure. Tesla had an idea that the light of the future might well be a suitably designed gas-filled tube energized by high-frequency currents (Fig. 8).

Because the Hertz apparatus was too feeble and inefficient and the spark coil was too impractical and dangerous for purposes of everyday lighting, Tesla first had to devise entirely new means for producing electricity of high frequency. His earliest attempts resulted in a series of ingenious high-frequency alternators which could deliver frequencies up to about 33,000 cycles a second. Besides serving his own early researches, these machines became the inspiration for the great high-frequency alternators developed by others for continuous-wave radio communication several decades later.

Tesla's next and better-known apparatus for producing currents of high voltage and high frequency was the oscillation transformer or "Tesla coil," an air-core transformer having the primary and secondary tuned to resonance. With this device, Tesla was able to convert the weak, highly damped oscillations of the original Hertz circuit to remarkably sustained currents of almost any magnitude desired. Starting with transformers which produced sparks only several inches long, Tesla, in 1899, built a Tesla coil at Colorado Springs which hurled a bolt of artificial lightning across a gap of 135 feet (Fig. 9). With characteristic thoroughness, he designed more than fifty types of oscillation transformer during a period of ten years—coils with cylindrical, conical, and flat windings, coils with oil insulation and with air insulation, coils with the primary encircling the middle of the secondary, and coils with the primary at one end, as in the "Oudin coil."

To increase the efficiency of these coils, Tesla developed rotary and series spark gaps, oil-insulated transformers and condensers, choke coils, and mica condensers impregnated with wax under a vacuum. Realizing that high-frequency currents travel near the surface of conductors, he cut down resistance in his coils by using stranded conductors having the strands separately insulated, a type of conductor that appeared commercially some years later as *Litzendraht*.

By the turn of the century, a Tesla coil for demonstrating high-voltage and high-frequency phenomena had become part of the equipment of probably every college science laboratory in America and Europe. In 1929—before E. O. Lawrence had introduced his cyclotron—Gregory Breit and his associates of the Carnegie

Institution of Washington were using a 5-million-volt Tesla coil, which they had designed and built, in pioneer attempts to smash the atom.

The fame of the Tesla experiments and apparatus was spread rapidly and widely by a series of remarkable lecture-demonstrations which Tesla gave before leading scientific societies; these lectures were published and discussed in technical journals, and they were reprinted in 1894 in Thomas Commerford Martin's book, *Inventions, Researches, and Writings of Nikola Tesla* (*11*).

In the first of these, "Experiments with alternate currents of very high frequency and their application to methods of artificial illumination," given before the American Institute of Electrical Engineers at Columbia University, New York, on 20 May 1891, Tesla noted that the earlier laws of electricity held good only when currents were of a steady character; that when currents rapidly changed in direction and strength, different laws applied; and that enough knowledge had been obtained to put these laws to practical use. By means of his high-frequency alternators and Tesla coil, he then demonstrated some of the novel effects produced by these new "Tesla currents."

One effect concerned the rapid heating of iron cores and conductors when brought within an intense high-frequency field—pioneer observations which were to lead Tesla and others to the application of high-frequency currents in melting metals and heating body tissues. In another demonstration, illustrating the importance of capacitance in a high-frequency circuit, he showed how motors could be run and lights lit with only a single terminal connected to the generator, the other being connected to an insulated metal plate. In a third demonstration he showed how gas-filled tubes, some coated with phosphors to increase their brilliance (forerunners of modern fluorescent lights, which were not to make their appearance until nearly half a century later), could be lit without any wire connection at all, merely by bringing them within a high-frequency field. The demonstration which caused the greatest wonder and consternation, however, was that in which Tesla lit lamps, held in his hands "like flaming swords," by several hundred thousands of volts of high-frequency electricity passing through his own body! Thus Tesla dramatized his answer to the accusation then circulating that alternating current was more deadly than direct current: provided the frequency were high

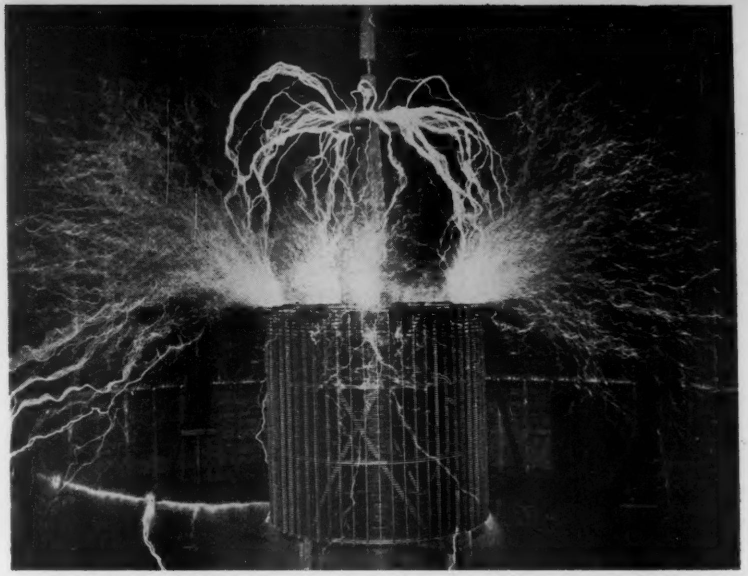

Fig. 9. A flamelike discharge, 65 feet across, from a tuned helix coupled to the primary of a giant oscillator built by Tesla at Colorado Springs in 1899 in his attempt to send power without wires by changing the electric charge of the earth. This oscillator was the largest Tesla coil ever built. Its true secondary, which could produce sparks 135 feet long, can be seen in the background, surrounding the helix.

enough, alternating current of enormous voltage could be completely harmless.

In 1892 Tesla delivered his second lecture, before the Institution of Electrical Engineers and the Royal Institution of Great Britain, in London, and the Société Internationale Française des Electriciens and the Société Française de Physique, in Paris, and in 1893 he delivered his third, before the Franklin Institute in Philadelphia and the National Electric Light Association in St. Louis. In these later lectures, Tesla not only discussed the lighting, heating, and resonance effects of high-frequency currents but suggested that communication could be made by means of them; he demonstrated (in his lecture of 1893) actual circuits and apparatus remarkably similar to those which were adopted subsequently by other inventors and which became standard for all wireless transmission until the introduction of the transmitting electron tube, several decades later (see Fig. 10).

First Radio-Controlled Weapon

Soon after beginning his researches on high-frequency currents, Tesla became interested in a new field of science which he named "telautomatics" and which we now call "automation"—the design and operation of electromechanical devices which could "think for themselves" and also the control of such devices from a distance without intervening wires. The idea had struck him after study of his own reactions to external influences, and he had come to regard himself as a sort of mechanism of flesh and blood. Why could he not construct an automaton possessed of sense organs, nerves, reflexes, and muscles which would respond much as he did to stimuli from outside? Using intricate combinations of commutators, gears, ratchets, electromagnets, tuning devices, and coherers of his own invention, Tesla set out to achieve this end.

By 1895 he had already exhibited contrivances which performed simple movements under wireless control and had perfected plans for constructing several complete telautomata. In 1897 he built and operated two model boats which could be started, stopped, steered, and made to flash lights and fire explosives by means of radio impulses from a distance (Fig. 11) and the following year Tesla was granted a patent on this invention.

According to the patent's broad specifications, Tesla's device could be used to control "boat, balloon, or carriage"; it could be operated by direct conduction through earth and water or by any form of electromagnetic radiation through the air; it could be used "for killing whales and for other scientific, engineering, or commercial purposes. But its greatest

value is in its effect on warfare and armaments for by reason of its certain and unlimited destructiveness it will tend to bring about and maintain permanent peace among nations."

In an article in the New York *Sun* of 21 Nov. 1898, "Torpedo to revolutionize warfare," Tesla explains further: "We shall be able, availing ourselves of this advance, to send a projectile at a much greater distance; it will not be limited in any way by weight or amount of explosive charge; we shall be able to submerge it at command, to arrest it in its flight and call it back, and to send it out again and explode it at will; and more than this, it will never make a miss. . . ."

While newspapers gave banner headlines to Tesla's radical contrivance as the doom of navies and the end of all war, more conservative technical men raised their eyebrows. "When we are expected to accept in silence such an utterance as that quoted above . . ." wrote the editor of the *Electrical Engineer,* "we refuse point blank, and we are willing to face the consequences." In another issue of the same magazine, C. F. Brackett of Princeton gave in detail his opinion of why a radio-controlled torpedo would not work: "What Tesla has done is merely to make theoretical application of inventions which had already been discovered . . . the theory is perfect, but the application absurd. . . . Do you suppose that in the din of battle it would be possible to put into execution those minute and carefully adjusted mechanical experiments all of which are presupposed by this theory, which require the uninterrupted quiet of a laboratory to work successfully?"

That Tesla not only conceived the idea and built working models of the first noninterferable, radio-controlled guided weapons but also, more than half a century ago, clearly foresaw the type of development necessary to lead to the marvelous missiles of today is strongly suggested in his article "The problem of increasing human energy," which appeared in the *Century Magazine* of June 1900: "The automatons so far constructed had 'borrowed minds,' so to speak, as each merely formed part of the distant operator who conveyed to it his intelligent orders; but this art is only the beginning. I propose to show that, however impossible it may now seem, an automaton may be contrived which will have its 'own mind,' and by this I mean that it will be able, independently of any operator, left entirely to itself, to perform, in response to external influences affecting its sensitive organs, a great variety of acts and operations as if it had intelligence. It will be able to follow a course laid out or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do, and of making experiences or, otherwise stated, of recording impressions which will definitely affect its subsequent actions. In fact, I have already conceived such a plan."

Tesla went on to say that the principle was applicable "to any kind of machine that moves on land or in the water or in the air," that the art he had evolved would not bring about "merely the change of direction of a moving vessel; it affords a means of absolute controlling . . . all the innumerable translatory movements, as well as the operation of all the internal organs, no matter how many, of an individualized automaton."

One of Tesla's original model boats did utilize far more intricate control apparatus than was indicated by his patent No. 613,809. To protect inventions he was not yet ready to disclose, he outlined only the basic idea in his specifications; besides, at the time his application was filed, utilization of the invention was seriously being considered by the United States Navy for help in our war with Spain. One of the features not revealed was a system to prevent interference by means of coordinated tuning devices responsive only to a combination of several radio waves of completely different frequencies. Another was a loop antenna which could be completely enclosed by the copper hull of the vessel; the antenna would thus be invisible and the vessal could operate completely submerged.

Turbines and World Wireless

Among other achievements, Tesla invented a turbine having smooth parallel blades and no buckets. The principle, which involved the surface drag of air, steam, or gas, was used in a device to couple the elements of a speedometer made for years by Waltham and used on many of our best cars. Tesla demonstrated synchronous electric clocks and hoped some day to power as well as synchronize them by radio. Although the means for producing sufficient power was not yet available, Tesla wrote in 1917 of plans for detecting ships and other distant objects by training on them a powerful ray of short-wave electrical impulses and then picking up the reflection of the ray on a fluorescent screen—a clear prophesy of the radar that was to come.

Tesla's great dream at the turn of the century was to send electric power without wires by making the whole earth

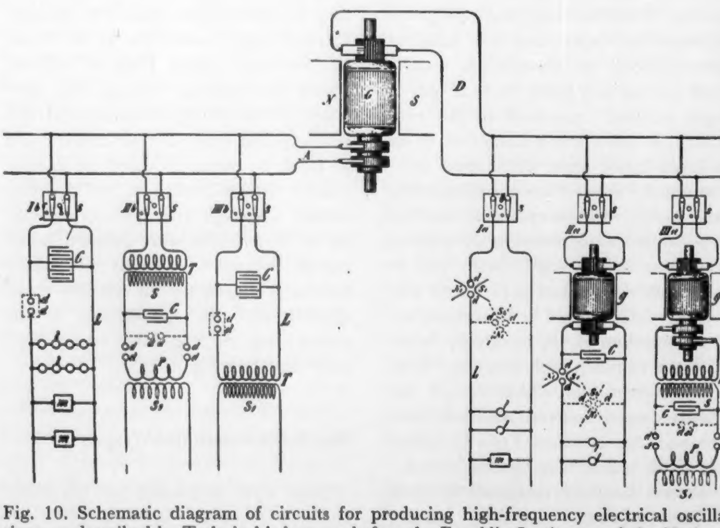

Fig. 10. Schematic diagram of circuits for producing high-frequency electrical oscillations, as described by Tesla in his lectures before the Franklin Institute and the National Electric Light Association in 1893. Circuits III*a* and II*b* contain all the basic elements of spark radio transmitters introduced a number of years later by Marconi and others; these remained standard for several decades. [T. C. Martin, *Inventions, Researches and Writings of Nikola Tesla* (1894).]

part of a gigantic oscillator. Convinced that this was possible by the results of his experiments at Colorado Springs in 1899 and 1900, he began construction of his first demonstration plant at Shoreham, Long Island, a few years later. Although Tesla ran out of funds before he could complete this plant, he outlined a "World Wireless" plan which was to be a subsidiary project; this anticipated not only the radio broadcasting of 20 years later but many of the special services that have been added since, and even a few that are still in the future.

Besides proposing to run and sychronize the clocks of the world by radio, Tesla included in this plan "the interconnection and operation of all the telephone exchanges on the Globe; the world transmission of typed or hand-written characters, letters, checks, etc.; the inauguration of a system of world printing; the world reproduction of photographic pictures and all kinds of drawings or records." Outlining his idea of broadcasting, Tesla continued: "I have no doubt that it will prove very efficient in enlightening the masses, particularly in still uncivilized countries and less accessible regions, and that it will add materially to general safety, comfort and convenience, and maintenance of peaceful relations. It involves the employment of a number of plants, all of which are capable of transmitting individualized signals to the uttermost confines of the earth. Each of them will be flashed to all points of the globe. A cheap and simple device, which might be carried in one's pocket, may then be set up somewhere on sea or land, and it will record the world's news or such special messages as may be intended for it."

His Work an Inspiration to Others

Beyond demonstrating his own achievements as a discoverer and inventor, Tesla's lectures and writings of the 1890's aroused wide admiration among older contemporaries and inspired untold numbers of younger men to enter the new fields of radio and electrical science. In some cases this influence has already been acknowledged in print. It is even more apparent in personal letters from more than seventy pioneers in science and engineering which I collected on the occasion of Tesla's 75th birthday, in 1931. These were mounted and presented to Tesla in the form of a testimonial volume, now on permanent display in the Nikola Tesla Museum in Belgrade.

Among those who expressed indebtedness and appreciation were Robert A. Millikan, Lee DeForest, William H. Bragg, E. N. daC. Andrade, E. V. Appleton, Arthur H. Compton, J. B. Whitehead, B. A. Behrend, André Blondel, Count George von Arco, Jonathan Zenneck, L. W. Austin, Addams S. McAllister, and W. F. G. Swann.

During his long life, Tesla accepted many conventional honors and turned down others. In 1894 he was given honorary doctoral degrees by Columbia and Yale Universities and the Elliott Cresson medal by the Franklin Institute. In 1917 the American Institute of Electrical Engineers awarded Tesla the Edison medal, and in 1934 the city of Philadelphia awarded him the John Scott medal, for his polyphase power system. He had many engineering and scientific society affiliations—was an honorary member of the National Electric Light Association and a fellow of the American Association for the Advancement of Science. In May 1938, as a foreign-born citizen "whose influence is national and international in scope, constructive in character, and purposeful in objective," Tesla, along with Giovanni Martinelli and Justice Felix Frankfurter, was awarded a scroll of honor by the National Institute of Immigrant Welfare.

Hypersensitive, aloof from other scientists of his day, driven by inner forces which made sheer creation the most important thing in his life (Fig. 12), Tesla was little impressed by degrees, scrolls, and decorations. He claimed that although he kept his American citizenship papers in a safe, he stored his honors and decorations in a dresser drawer. On one occasion he turned down an invitation from Kaiser Wilhelm II to come to Germany to demonstrate his experiments and to receive a high decoration, and on another he missed getting an honorary degree from a western American university because he was unwilling to take time from his work to attend the ceremony.

Like many another dedicated artist and scientist, Tesla had no regard for money except as a means to further his inventive work. He also naively believed that money would automatically flow to him in proportion to his needs. To help his friend George Westinghouse out of a financial scrape—and incidentally to provide himself with immediate cash for new ambitious experiments—Tesla let

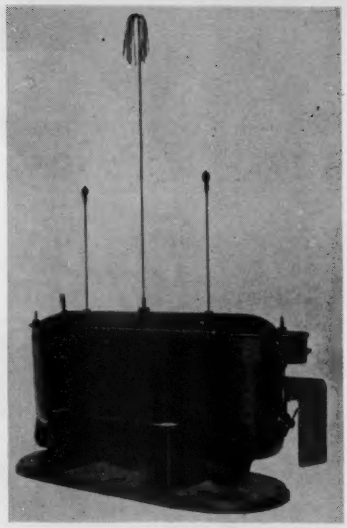

Fig. 11. Model of Tesla' first automaton, built in 1897, the year Marconi took out his first U.S. patent for wireless telegraphy. The boat model shown in the photograph is controlled, without the use of wires, by transmission from a distance of electrical oscillations to a circuit carried by the boat and adjusted to respond only to those oscillations. This and other "telautomatic" devices developed by Tesla between 1892 and the early 1900's provided the concept which led finally to the development of today's guided weapons. [Illustration from N. Tesla, "The problem of increasing human energy," *Century Magazine* (June 1900).]

millions of dollars slip through his hands by scrapping a lucrative royalty contract for his polyphase inventions for an outright payment. According to legend, this payment was a flat $1 million, made personally to Tesla; cold business reports, however, place it nearer $200,000, paid to the Tesla Electric Company, of which Tesla owned only a one-third interest.

Although the experiments, apparatus, and prophecies of Tesla's lectures in 1891–1893 were admittedly the inspiration for many of the prominent pioneers of radio communication who came later, and earned for Tesla the title of "father" of wireless, or radio, from such authorities as Adolph Slaby, the "Marconi of Germany" (*12*), and L. W. Austin, long head of radio research of our National Bureau of Standards (*13*), Tesla got little or no money from his wireless inventions.

Believing that mere point-to-point communication by means of Hertzian waves was an obvious application of Hertz's own experiments of 1887, Tesla

Fig. 12. A bust of Nikola Tesla made after his death by the internationally renowned sculptor Ivan Mestrović. The original plaster model is on exhibition at the Yugoslav Academy of Art and Science in Zagreb, Yugoslavia, and bronze replicas are displayed in the Technical Museum in Vienna and the Tesla Museum in Belgrade.

made no attempt to apply and patent his early apparatus for this purpose. Instead, he flung his imagination into trying to devise a new and more efficient system of wireless wave transmission which could convey not only messages but also power for light and motors. He never completely succeeded, but in his efforts Tesla incidentally—and ironically—produced some of the most advanced Hertzian apparatus of the day, apparatus which was eagerly adapted by others for less ambitious but more profitable and immediately productive purposes.

Tesla understood well the nature of Hertzian waves and constantly used them. His obstinacy in refusing to admit that these waves played a significant part in the operation of his wireless power equipment—which they undoubtedly did—merely helped confuse judges and lose cases for him throughout his lifetime. It was not until several months after Tesla's death that the United States Supreme Court, in continuing a suit held over from World War I, declared Marconi's four-circuit wireless patent—his most important—invalid because the four-circuit wireless had been anticipated by Tesla, John Stone Stone, and Oliver Lodge (*14*). Stone and Lodge, incidentally, had found inspiration for the inventions cited in this case in the earlier lectures of Tesla.

Tesla's wireless power experiments at Colorado Springs were financed largely by his friend John Jacob Astor; his turbine was financed by John Hays Hammond, and his experimental wireless power station at Shoreham, Long Island, by J. P. Morgan. Because Tesla could not get enough additional capital to finish the latter, it finally had to be abandoned, untried.

Unwilling, and actually unable by temperament, to work with the commercial experimental organizations that had gradually taken the place of the individual self-supported inventor, Tesla spent his later years, alone and without funds, feverishly working over in his mind the dreams which he could no longer afford to translate into physical actuality. No one could really have helped him. Tesla accepted pain and hardship philosophically, as essential to all great creative work. If someone gave him a modest amount of money he would either be offended or, on impulse, give it to someone he thought needed it more. Once, when he had nothing, he laughingly confided to me that "I will never have any money unless I get it in amounts so large that I cannot get rid of it except by throwing it out the window!"

In 1937, while taking one of his daily long walks about New York, Tesla was hit by a taxi. With his usual obstinacy he refused medical attention and continued walking, on the theory that this would keep his blood from clotting. Tesla never fully recovered from this accident. During the following years he kept himself shut up more and more in his room in the Hotel New Yorker. He was seldom willing to see old friends, and his voice over the telephone became feebler and his thoughts less coherent. On the morning of 8 January 1943, a maid knocking on the door of his room got no response. Nikola Tesla was dead. Hidden from the flashing neon signs, rumbling subways, blaring radios, and light and power in a million homes of the city which had become the symbol, for the world, of the modern age of electricity which he had so largely helped to create, Tesla had died in the night, as quietly as he had been born.

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7. C. E. L. Brown, in letter from Baden, Switz-

erland, dated 12 Oct. 1891, published in *Elec. World* (*N.Y.*) 1891, 346 (7 Nov. 1891).

8. Arago had merely arranged a disk of copper below a compass needle with a sheet of paper or glass between them to shield the needle from air currents. When the disk was turned, the needle would tend to revolve in the same direction, pulled by the interaction of its own magnetism and that set up in the rotating disk. Arago could not correctly explain the working of his device and did nothing further with it.
9. Diagram from a paper, "The installation of the Niagara Falls Power Company," given by C. F. Scott before the Engineers' Club of Philadelphia, 17 Apr. 1897; the diagram was reprinted in E. D. Adams, *Niagara Power* (Niagara Falls Power Co., 1927). Scott later became professor of electrical engineering of the Sheffield Scientific School of Yale University.
10. From minutes of the meeting of the American Institute of Electrical Enigneers of 18 May 1917, at which Tesla was awarded the Edison Medal. Buck was then president of the institute.
11. These lectures, together with Tesla's lecture on polyphase motors, most of his patent specifications (complete with drawings), and 25 of his most important articles have been reprinted in a memorial volume, *Nikola Tesla—Lectures, Patents, Articles* (Nikola Tesla Museum, Belgrade, 1956).
12. A. Slaby, in a personal letter to Tesla, now in the Tesla Museum.
13. L. W. Austin, in a personal letter to me, dated 14 June 1927: "The 1891 lectures, published in 'Inventions, etc. of Nikola Tesla' in 1894, I am sure, furnished the material for at least some of the inventors who developed the coupled tuned circuits which came into use about 1900 and constitute Mr. Tesla's right to be called the 'father of radio.' "
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A Theory of Ice Ages II

The theory that certain local terrestrial conditions caused Pleistocene glaciation is discussed further.

Maurice Ewing and William L. Donn

In a recently proposed theory of ice ages (*1*) we formulated the thesis that (i) the Pleistocene Ice Age was initiated when the North and South poles migrated into the thermally isolated locations of the Arctic Ocean and Antarctica, respectively, and that (ii) fluctuations of glacial with interglacial climate during the Pleistocene epoch were controlled primarily by alternations from an ice-free to an ice-covered state of the surface waters of the Arctic Ocean. According to this theory, the local terrestrial conditions of thermal isolation and adequate precipitation, rather than broad, world-wide changes of terrestrial or extraterrestrial origin, should be emphasized as the causes of Pleistocene glaciation.

Further Notes on the Northern Hemisphere

Despite the feeling of some authorities that the effects of an open Arctic Ocean would be quantitively insufficient to cause the amount of glaciation that existed, the validity of the theory seems to be illustrated by present conditions in the Arctic and Antarctic regions.

Thus, the unexplained glacial conditions which have continued in Greenland since the Pleistocene contrast very sharply with the present ice-free condition of northern Canada at the same latitudes. The significant geographic difference between Greenland and northern Canada is their location with respect to the North Atlantic Ocean. As a result of the location of Greenland, there is enough moisture in its atmosphere to cause sufficiently heavy precipitation of snow for the maintenance of glacial conditions, whereas the very scanty precipitation at the same latitudes in Canada results in the present lack of glaciers there. Also, the precipitation in the southern part of Greenland is much heavier than that in the northern part. Hence, an open Arctic Ocean during the Pleistocene seems to be the only geographic condition which could have produced glacial conditions in northern Canada equivalent to those in Greenland today. Further, the effects of the combination of thermal isolation and adequate precipitation can be seen from a comparison of present conditions in the Arctic and Antarctic areas. The thick Antarctic icecap contrasts sharply with conditions in the Arctic Ocean area, with the exception of those in Greeland. This can be explained by (i) the more complete thermal isolation of Antarctica than of the Arctic (the condition in the Arctic is the result of the small interchange of water between the Arctic and Atlantic oceans, without which interchange the Arctic Ocean would have a permanently thick frozen cover); and (ii) the availability of moisture from the surrounding open oceans for snow precipitation on Antarctica. Such precipitation is very slight over the nearly completely landlocked Arctic.

Greenland is similar to Antarctica in being thermally isolated, in being bounded largely by open water, and in having an icecap equivalent in thickness to that of the icecap in Antarctica. Greenland is also similar to Antarctica in that its icecap was probably maintained with little change during the Pleistocene interglacial stages. The following observation recorded by Charlesworth (*2*, vol. 1, p. 94) certainly supports this: "The Pleistocene ice sheets had a maximum thickness . . . which significantly enough is roughly that of the modern ice sheets of Greenland and Antarctica." In view of these conditions, we may expect the Greenland and Antarctic icecaps to be preserved, with minor fluctuations, as long as the Poles are located in their present positions.

Thus, the present contrast between Greenland and northern Canada and that between the Arctic and Antarctic regions, which result from local conditions, are comparable to contrasts between glacial and interglacial stages and make it a plausible conclusion that the latter are also the results of restricted terrestrial changes rather than of global or extraterrestrial causes.

Further evidence that there was formerly a source of precipitation in the Arctic region lies in the position of the glacial divide, as determined from indicators of ice movement and glacial re-

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bound. On the basis of indicators, J. Tuzo Wilson (*3*) shows that the divide ran approximately east-west through central Canada, except where its course was controlled by topography. Earlier notions based on the highest elevations covered by ice, as summarized by Flint (*4*), and deductions based on the theory that the source of nourishment was to the south (*5*), have placed this ice divide much further to the south. Also, detailed studies of ice movement in Alberta (*6*) show that movement was from the north rather than from the northeast, as had previously been supposed.

Although Lee *et al.* have applied the above data on motion indicators to late glacial conditions (*7*), the data of glacial rebound suggest, also, that the North American Wisconsin ice divide lay in the vicinity of Hudson Bay, thus giving independent supporting evidence for the existence of a source of precipitation to the north of the terminal moraine line in the eastern half of North America. The evidence for uplift northward is best given by the elevated beaches of the present Great Lakes and the ancient Lake Agassiz (*2*, vol. 2, p. 132; *4*, pp. 250–251; *8*). An uplift of six to eight inches per 100 miles per century is given for these areas. Uplift determined from elevated areas around Hudson Bay reaches a maximum of 1000 feet (*2*, vol. 2, p. 1321) and is continuing at present (*9*) at an undetermined rate. If the data from the Great Lakes region is extrapolated through Hudson Bay, it seems clear that a continuous thickening of ice occurred from the present hinge line northward to the Hudson Bay region.

Blake's study (*13*) indicates that rebound in Labrador is less than that around Hudson Bay and supports the location of the divide shown by Wilson.

Glacial rebound on northern Ellesmere Island and Ward Hunt Island (about 83°N) varies from 100 to 200 feet along the shore to at least 600 to 700 feet further inland (*11*), thus approaching the magnitude of the uplift at Hudson Bay, far to the south. This suggests and supports still further the argument that there must have been a source of moisture in the Arctic region.

The Southern Hemisphere

We wish to elaborate here on the statement in part I of this discussion (*1*) to the effect that Pleistocene glaciation in the Southern Hemisphere regions other than Antarctica and the sub-Antarctic islands was mainly limited to high elevations and was consequent upon the general cooling produced by the much greater change in the Northern Hemisphere.

From the excellent summaries of Charlesworth (*2*, vol. 1, p. 44; vol. 2, p. 1322) and Flint (*4*), it is noted that in South America glaciers extended along the Andes, with a few gaps, from Cape Horn to Sierra Nevada de Santa Marta in Colombia. The glaciers broadened considerably on Tierra del Fuego and on the plains east of the mountains in Patagonia. Pleistocene glaciation in Africa was confined to the Atlas Mountains of French Morocco and the high mountains of Equatorial East Africa, both of which areas have perennial snow fields today. In Australia, barely 150 square miles in the Australian Alps were glaciated, and upland areas of South Island (New Zealand), and of Tasmania (both south of 40°S) were extensively glaciated. Thus, except for Tasmania and the smaller region in Australia, it is noted by Charlesworth (*2*, vol. 1, p. 44; vol. 2, p. 1322) that Pleistocene glaciers were merely extensions of the glaciers that remain today in New Zealand, the Andes, and Africa. Further, with the exception of Auckland and the Macquarie Islands, the sub-Antarctic islands also have existing glaciers which were more extensive in Pleistocene time.

A moderate lowering of the snow line in the Southern Hemisphere, which will confirm the foregoing reconstruction of glacial conditions, is expected to result from the global cooling produced through the effects of glacial and pluvial conditions in the Northern Hemisphere upon the radiation and heat budgets of the earth.

A planetary decrease in the amount of absorbed insolation would result from a rise in albedo of the Northern Hemisphere. This would follow from the greater reflectivity of the ice in glaciated regions and of the clouds in the pluviated regions (the latter to be described in detail below.)

The areas in the Northern Hemisphere which were ice-covered during the Pleistocene glacial stages and are ice-free today cover 10.7 million square miles and are distributed around a latitude of 60°N. If we assume a mean cloudiness of 60 percent for this region in both glacial and nonglacial stages, the albedo in the remaining 40 percent would be raised from 10 to 70 during a glacial interval. If 300 calories per square centimeter per day (*12*) is taken as the mean insolation received at the surface at a latitude of 60°N, then the resulting decrease in insolation available for absorption in the glaciated areas is 2.0×10^{19} calories per day.

Further, as will be described in detail below, about 12 million square miles of arid regions were well watered (pluviated) during glacial stages. The mean cloudiness of these regions, which are distributed around latitudes of 30°N and 30°S, is about 20 percent at present. If an increase in cloudiness to 60 percent (a figure based on present equivalent areas) during the glaciopluvial stages is assumed, the albedo of these desert regions would increase from 15 (for sand) to 80 (for clouds). If 470 calories per square centimeter per day (*15*) is taken as the mean surface insolation, the increased albedo would result in a decrease of absorbable insolation of 4×10^{19} calories per day for the pluviated zones. A total reduction of 6.0×10^{19} calories per day would thus occur for the combination of glaciated and pluviated regions. (The difference in albedo between sea ice and rough water in high altitudes is so small that no significant change in this estimate would occur if the Arctic Ocean were open during a glacial stage, as postulated by our theory.) This is a significant percentage of the direct insolation of 85×10^{19} calories per day for the entire earth. It is noteworthy that the terrestrial changes described seem capable of reducing the radiation budget of the earth without reliance upon extraterrestrial changes, and thus of producing a sufficient degree of cooling to bring about glaciation in the Southern Hemisphere. It is also noteworthy that the pluviated regions are at least as important as the glacial areas in promoting global cooling. In the foregoing calculations, no account has been taken of the small effect of absorption in the atmosphere.

Although it is generally admitted that uplift of land areas results in cooling of such regions, it should also be noted that a minor contribution to the general cooling of the lands would also result from the glacial lowering of sea level, since a change of 300 feet in sea level produces an average change in temperature of 1°F.

Antarctica

The field evidence available for an estimate of the effect of the continental ice budget on Antarctica during Wiscon-

sin time is scanty and inconclusive at present. Similarly, the conclusions about the Antarctic ice budget that can be derived from existing theories of glaciation are quite ambiguous. Thus, the Antarctic icecap appears to be in approximate equilibrium at present with regard to height (*13*) and lateral extent. Yet evidence in the form of exposed glaciated mountain areas exists to indicate that there was a former higher equilibrium stand of the icecap. Most authorities place this higher stand in Wisconsin time. Theories of glaciation require the assumption that, for the most part, the ocean and air surrounding Antarctica were cooler during glacial stages. Such conditions would produce a decrease in snow precipitation over Antarctica which would more than offset the decrease in wastage which results from lowering of temperatures. It is difficult to conceive of there having been glacial growth on frigid Antarctica during times when the surrounding environment was cooler than it now is. It seems more reasonable to suppose that former higher levels of the icecap were a result of growth during interglacial stages or even during the more recent climatic optimum. Possibly the continuing study of Antarctica will provide information for the dating of this higher stand; this is at present an unsolved problem.

Pluvial Stages

The effect of the Pleistocene conditions of moisture in presently arid areas is second in importance only to the contemporaneous glaciation in higher latitudes. The major desert areas, which are today uninhabited barren wastes, although they occupy a very large part of the temperate zones, were formerly fertile, well-watered lands (*14*). These areas, which were often covered by very large lakes, include the Sahara and Arabian deserts, the desert of central Asia, and the Australian Kalahari, the North American, the Atacama, and the Patagonian deserts. No theory of glaciation and no investigation of Pleistocene glacial stages would be complete without an explanation of the pluvial stages and their relation to glaciation.

Although there is a considerable amount of evidence which suggests strongly that pluvial and glacial conditions occurred simultaneously, the most positive evidence for this comes from Lake Lahontan in western North America (*15*).

The Lahontan data refer only to the end of the last glacial stage, but very strong evidence for glacial-pluvial simultaneity comes from observations around the Caspian and Black seas. According to P. F. Fedorov, every transgression of the Caspian Sea which occurred during glacial advances of Pleistocene time coincides, without exception, with a regression of the Black Sea (*16*); hence, it seems that pluviation was contemporaneous with glacial lowering of sea level throughout the Pleistocene period.

The predominant cause of present-day deserts is their location in either the belt of subtropical calms (the horse latitudes) or in the trade wind zone marginal to this belt; in these zones the dry air moves equatorward, becoming warmer and thereby able to carry increased amounts of moisture. A secondary cause is the location of these deserts on the lee sides of mountains and along coasts bathed by cool ocean waters. Some desert areas are the result of a combination of all these causes.

The higher stands of many lakes and rivers during the glaciopluvial stages were the result of the snows and meltwater of adjacent glaciers. But the largest of these pluviated regions, including most of the present-day deserts, were so remote from glaciated areas that the cause of pluvial conditions must be other than simple proximity to glaciers. The fact that there has been widespread rainfall in the past over broad areas which are not only arid at present but which lie in climatic zones where conditions are basically unfavorable for the formation of rain in significant amounts indicates strongly that a fundamental modification of the atmospheric circulation must have occurred during the glaciopluvial stages.

In part I of this discussion (*1*), the theory was advanced that the present north-polar high-pressure area is a reversal from a polar low, which resulted from the contrast in temperature between the relatively warm, open Arctic Ocean and the surrounding cold, glaciated continents. Further, it was stated that the Iceland low-pressure area, which at present weakens in summer and intensifies in winter, probably migrated southward during glacial stages. By an extension of the reasoning involved, it is possible to construct a model of modified circulation which could account for the pluvial conditions that have been described for the present major desert areas. The critical changes in circulation, which have been described, in principle, by a number of investigators in the past, are outlined below.

1) During a glacial stage, the Iceland "low" of the North Atlantic would migrate southward and would maintain present winter intensity all year as a result of the perennial temperature contrast between the cold glaciated continents and the relatively warm ocean. Increased storm intensity and frequency would therefore persist throughout the year, the paths of the storms being deflected far to the south of the present paths.

2) At present, the belts of subtropical calms (the horse latitudes) are located at approximately 30°N and 30°S and show greater intensity over the oceans in summer than in winter. During a glacial stage, this zone would also migrate southward in the strongly glaciated Northern Hemisphere and would probably weaken over the oceans because of the persistence of cold conditions over the continents.

3) The combination of an icecap extending into the middle latitudes, or present Temperate Zone, plus the southward migration of both the Iceland low and the horse latitudes would result in the southward displacement of the entire zone of the prevailing westerlies wind belt and hence of the entire belt of migratory cyclonic storms which predominate in this belt. These storms would consequently travel well into the regions which, at present, are deserts because they lie in the dry horse latitudes and adjacent areas.

4) Owing to the changes described above, polar air masses originating over the icecaps in the middle latitudes would tend to meet the extremely moist equatorial air much more frequently than at present, thereby generating very intense storms which would yield the very high precipitation characteristic only of hurricanes today.

5) Although in general it would be cooler than at present as a result of widespread global cooling during a glacial stage, the low-pressure doldrum belt would become relatively stronger through contrast with the very cold belt of the middle latitudes. Further, this belt, now located north of the equator in the vicinity of continents, would probably be displaced somewhat to the south of the equator as a result of the pronounced cooling of the northern continents. This would tend to increase the amount of moisture over the present desert regions of the low southern latitudes of South America and Africa, thus increasing precipitation over the deserts of South

Africa and the west coast of South America.

6) As a result of the present monsoon pattern in southern Asia and the Indian Ocean, the doldrums are located over Australia during the northern winter. With glacial conditions existing over the northern continents, the present winter-type pattern would tend to become semipermanent, bringing considerably more moisture and precipitation to Australia. It is a well-known fact, established from the fossil record [see Benson (*17*)], that, during the Pleistocene, large fauna with tropical affinities inhabited Australia. This and the pluvial conditions of central Australia can be explained by the theory of the change in circulation; the small high-altitude glacier of southern Australia could have existed in much the same manner as do equatorial glaciers on the mountain areas of Africa and South America at present (*18*).

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K. P. Schmidt—Herpetologist, Ecologist, Zoogeographer

Karl Patterson Schmidt died on 26 September 1957, at the age of 68, as the result of a bite by a boomslang the previous day. The snake had been brought from the Lincoln Park Zoo to the Chicago Natural History Museum for identification. The boomslang is an African "back-fanged" snake, widely but erroneously considered to be less dangerous than the front-fanged cobras and vipers. Moreover, this one was a juvenile and was therefore not expected to carry much venom. Schmidt did not consider the bite serious and took no preventive measures to reduce the toxic effects. He kept an account of his reactions to the poison, including the nausea and hemorrhages, but showed no indication that he anticipated death up to the moment he lapsed into a coma from extensive brain hemorrhages. Exactly a month before his death, he said in his last sentence in a published note in *Copeia* (1957, page 233), "one scarcely needs to be warned that a pit-viper with inch-long fangs is dangerous, whether aggressive or not, quite as one needs to be cautioned against the apparent harmlessness of coral snakes." His friends fervently wish he could have exercised this caution against the back-fanged boomslang as well. Dramatic as was his death, which was given wide publicity in the newspapers of the country, of far greater import was his continuous contribution to scientific knowledge and to education throughout his long professional life.

Karl Schmidt was born at Lake Forest, Illinois, in 1890, where his father was a professor of German in Lake Forest College. He began his focal interest in science at the Lake Forest Academy, and he completed his freshman year at the college with much distinction. Before he went to Cornell University for further undergraduate training in biology and paleontology, he spent six years on the family farm at Stanley, Wisconsin, where he helped clear its timber and establish a dairy farm. Particularly during this period he developed an intense interest in natural history, and his enthusiasm for the observation of nature was the central theme of his subsequent life. He had a remarkable ability to transmit this interest to younger men (I was one of those who felt his influence), and many scientists in various fields owe much of their initial inspiration to Schmidt. He started on his long series of field explorations while still an undergraduate, first as a geologist and later as a biologist. His developing professional interest was greatly augmented by his teachers and friends, among whom were J. G. Needham, J. H. Comstock, Anna B. Comstock, G. D. Harris, and A. H. Wright.

He was married in 1919 to Margaret Wightman, and together they immediately sailed to Puerto Rico on an expedition for the New York Academy of Science. Throughout their married life, Margaret Schmidt added a balance and an integration to their lives which unquestionably were major factors in her husband's productivity. She and their two sons, John and Robert, survive him.

Schmidt became assistant curator of reptiles and amphibians at the American Museum of Natural History in 1918. He joined the staff of the Chicago Natural History Museum in 1922, where he rose from assistant curator of reptiles and amphibians to curator, and then to chief curator of zoology in 1941. At the time of his retirement from administrative duties, in 1955, a volume with contributions by many of his associates was published in his honor (*Fieldiana: Zoology*, vol. 37, 1955).

He was a steady contributor to scientific journals and wrote nearly 150 articles and books on his researches in herpetology. He was former herpetological editor of *Copeia*, section editor of *Biological Abstracts*, and editor of the zoological journals of the Chicago Natural History Museum. He was author or joint author of several books on zoological subjects, among them *Ecological Animal*

Geography, by Hesse, Allee, and Schmidt, and *Principles of Animal Ecology,* by Allee, Emerson, Park, Park, and Schmidt. He was an avid reader of the classics in natural history and was keenly interested in the personalities in this field. He was always able to bring historical perspective into his discussions of modern biological problems. He had been chosen to coordinate and edit the volume of essays by prominent students of evolution to be published in connection with the Darwin Centennial Celebration at the University of Chicago in the fall of 1959. He was skilled in speaking to both professional and nonprofessional audiences, and his humor and human sensitivity brought forth enthusiastic responses from his listeners. He could establish rapport with natives in the South Seas or in Central or South America and with oil-drillers, farmers, and university students alike. He was sincere and earnest in everything he undertook, his enthusiasm for life and for knowledge was contagious, and his feeling for the highest human values made him religious in the most fundamental meaning of the term. Although he was essentially a modest and rather self-effacing person, he was also strong in his opinions and forceful in his denunciations.

He was honored by many organizations. He held a Guggenheim fellowship in 1932, was president of the Society of Ichthyologists and Herpetologists from 1942 to 1946, was president of the Society for the Study of Evolution in 1954, and was elected to the National Academy of Sciences in 1956. Earlham College granted him an honorary degree of Doctor of Science in 1952. He received the citation of "Eminent Ecologist" at the 1957 meeting of the Ecological Society of America at Stanford.

He had great influence in bringing about cooperative relations between individuals and organizations alike. The active participation of the Chicago Natural History Museum in joint programs with the University of Chicago and the Chicago Zoological Park at Brookfield stems in part from his understanding of personalities and projects. He had great faith in the present and future functions of museums as scientific and educational institutions and planned to write a book on this subject.

I have given a brief summary of his activities and a few indications of the regard in which he was held by his colleagues and associates in both national and local affairs, but I venture to say that even more lasting will be the personal and emotional influence he had on his family, on his friends, and particularly on his younger associates both in the United States and in foreign countries. Throughout my own long friendship with Karl Schmidt, I often sought his counsel on scientific matters, and I collaborated with him in the writing of one book. We were associated in the organization of both national and local societies. But I miss him even more for his human qualities, his honesty, and his selflessness than for his objective scientific knowledge, judgment, and understanding, and I feel sure that countless others react to his tragic death as I do.

Those who wish to understand some of the qualities of the man and of the scientist may gain insight from his beautiful tribute to his friend and collaborator, W. C. Allee [in *Biographical Memoirs* (National Academy of Sciences, 1957), vol. 30]. Those who wish to express their affection and gratitude in a tangible way may contribute to a fund in his honor that will be used to facilitate study by visiting scientists at the Chicago Natural History Museum. Donations should be sent to the Karl P. Schmidt Fund at that institution. The money contributed by his friends and colleagues will assist young naturalists in a manner close to his known desires.

We may well use Schmidt's own words at the end of his biography of E. R. Dunn [*Copeia* **1957**, No. 2, 77 (1957)]. "Let us therefore write not only farewell, to our friend, but hail to our colleague's enrichment of our science." And I would add, "and of our lives." In a poem entitled "Ecological Imperative" (1955), he concluded:

> What then is wisdom's last conclusion?
> What do freedom and salvation mean?
> He alone is saved whose life is lost
> In love of others, or of other, than
> himself.

Alfred E. Emerson
Department of Zoology,
University of Chicago

News of Science

International Oceanographic Congress

The AAAS, in cooperation with UNESCO and the Special Committee on Oceanic Research of the International Council of Scientific Unions, is organizing an International Oceanographic Congress to be held from 30 August to 12 September 1959 at the United Nations Building, New York. The purpose of the congress is to provide a common meeting ground for all sciences concerned with the oceans and the organisms contained in them. The congress will be devoted to the fundamentals of the marine sciences rather than to their applications.

It has been agreed by the organizing committee that the congress will be centered around the following five symposia on the oceans.

1) "The history": discussions of the shape and structure of the ocean basins, the acting forces and processes, the origin of sea water and marine organisms, the stratigraphy of the deep sea, and the climatic record.

2) "The boundaries": discussions of the coupling of sea and air, sea level, epicontinental sediments, estuarine and near-shore circulation (including the estuarine environment), influence of land masses on the behavior and distribution of marine organisms, and surface films and their importance in exchange processes.

3) "The deep sea": discussions of the geochemistry and physics of circulation, stirring and mixing in the ocean, nature and origin of bathypelagic life, distribution of pelagic sediment types (biological and physical interpretations), nuclear processes in pelagic sediments, and special characteristics of abyssal organisms.

4) "Dynamics of organic and inor-

ganic substances": discussions of physical chemistry of sea water, biologically active substances in sea water, primary production, balance between living and dead organic matter in the oceans, exchanges between sea and air, exchanges between sediments and sea water, and vertical transport in the ocean.

5) "The marine life regime": discussions of the paleogeography of marine floras and faunas, biogeographical regions in the sea, evolution and adaptation in the sea, behavior of marine organisms as influenced by environmental factors, physiology of marine plants, and culture of marine organisms as a means of understanding environmental influence on populations.

Each symposium topic will be considered for two consecutive days. Three invited lectures will be given each morning. The afternoon sessions will be organized around the topics of the morning lectures, either as round-table discussions, seminars, or series of papers. Several groups may run concurrently. Papers for the afternoon sessions will be selected from those received in response to preliminary announcements. Not all papers accepted will be presented, but all accepted papers will be available at the meeting in mimeographed form. Titles and abstracts should be submitted as soon as possible and in no case later than 1 February 1959. The completed papers must be submitted by 1 May 1959 in order to allow time for duplication and distribution to those who will participate in the afternoon meetings. All papers must be accompanied by an abstract in a second language of the congress. Papers may be presented in English, French, German, Russian, or Spanish. Simultaneous translations will be available for at least some of these languages.

The organizing committee expects that contemporary advances in the marine sciences, rather than reviews of older published work, will be presented within these broad categories. It is hoped that the younger staff members of the various oceanographic laboratories throughout the world will be encouraged to attend and to take part in the congress. The committee hopes to obtain funds to help defray the travel expenses of these younger participants. The committee also hopes to be able to contribute towards the travel expenses of the invited speakers at the morning sessions.

Titles and abstracts of papers and any other correspondence should be addressed to Dr. Mary Sears, Chairman, Woods Hole Oceanographic Institution, Woods Hole, Mass. Other members of the Committee on Arrangements for the congress are Gustaf Arrhenius, John Cushing, Henry M. Stommel, Fritz Koczy, George S. Myers, Roger Revelle, Gordon Lill, Lionel A. Walford, and Dael Wolfle (ex officio).

Family Planning in the U.S.S.R.

Interest in family planning is spreading rapidly in the U.S.S.R., according to Abraham Stone, vice president of the Planned Parenthood Federation of America and director of the Margaret Sanger Research Bureau. Stone went to Moscow this winter, by official invitation, to speak on social and technical aspects of contraception before the Soviet Union's Tenth National Conference of Gynecologists and Obstetricians. He says of his trip:

"This conference was the first official meeting of gynecologists in 22 years and provided an unusual opportunity to present the subject of family planning before Soviet physicians. The background of Soviet policy on family planning is helpful in evaluating the developments now taking place. In 1920, abortions were made legal in Russia, and a few years later, the Soviet Health Ministry became keenly interested in birth control as a means of fighting the growing abortion rate. They set up a special scientific committee on contraception, developed a fairly wide birth control propaganda, established birth control centers in many hospitals, began to produce contraceptive materials, and even pioneered in the development of newer methods and techniques.

"In 1936, for one reason or another, the abortion law was rescinded, and official work in contraception also virtually ceased. Although production of contraceptive materials continued and although these materials were sold in drug stores, there was little medical interest in the subject.

"In November, 1955, Soviet policy changed again and abortions were legalized once more. The circle is now being completed. Again the Soviet Health Ministry has become very much concerned about the large number of abortions and its potential harm to women, and has recognized the need for disseminating contraceptive information.

"It was in this spirit of awakening medical interest in contraception that I was invited. The conference was held from December 11 to 18 in the Dom Soyusov, one of the largest halls in Moscow. It was attended by some 2000 Soviet delegates, and by about 125 delegates from adjacent countries—Bulgaria, Czechoslovakia, East Germany, Poland, Rumania and Yugoslavia. There were also representatives from China, Switzerland, France, India, Belgium, Turkey, Iran and Mongolia. I was the only U.S. physician. Foreign delegates were seated in a special section, and speeches and discussions were translated simultaneously into English, French and German.

"At a plenary session, I spoke to the entire body on current research in contraception, outlining the methods presently employed in Western countries and the experimental work in progress to develop newer, simplified chemical and biological techniques. At a special film session on the next day, the Sanger Bureau film on biology of conception and techniques of contraception was shown several times.

"Physicians from all parts of the Soviet Union were eager to obtain more specific information on modern techniques, available products and formulae, and current research developments. So great was the interest that I was asked to enlarge my report for publication in the medical newspaper published by the Health Ministry, *The Medical Worker* (*Meditzinsky Rabotnik*), which reaches most physicians.

"I also left with the Ministry, at their request, a print of the film, the teaching mannequin which we use, samples of contraceptive products, and books and pamphlets.

"In spite of Marxist ideology, which regards as unimportant the effect of population growth on world economy and peace, there is every evidence that developments in the field of contraception will now take place rapidly. A special scientific committee is being organized again and will concern itself to a considerable degree with research in the field of contraception. New centers are to be established and a teaching manual on contraceptive techniques for physicians is planned. The new attitude is based on the belief that motherhood should be conscious; that parenthood should be voluntary; and that it is far better to prevent a pregnancy than to interrupt it."

Pulmonary Alveolar Proteinosis

An apparently new lung disease, pulmonary alveolar proteinosis, was described by Samuel H. Rosen of the Armed Forces Institute of Pathology, Washington, D.C., at the annual meetings of the International Academy of Pathology and the American Association of Pathologists and Bacteriologists, which took place in Cleveland between 21 and 26 April. Resembling pneumonia in some respects but clearly differing from it in microscopic examinations, the new disease appears to be caused by some injurious inhalant. Rosen presented data on 27 patients observed by him and Benjamin Castleman, Massachusetts General Hospital and Harvard Medical School, and Averill A. Liebow, Yale University School of Medicine.

First occurrence of the disease was observed at Massachusetts General Hospital in July 1953. Since then it has been detected in all parts of the United States and in Canada, England, and Italy. The appearance of the disease under the microscope is so highly individualistic that

it is unlikely it could have escaped description if it had been previously observed. The conclusion is that either the prevalence of the disease has increased greatly or there is a new agent, as yet unidentified, in the environment.

Symptoms are shortness of breath, usually associated with cough and sometimes with fatigue and loss of weight. The characteristic of the disease is the filling of the alveoli with granular proteinaceous material. There is little or none of the inflammatory reaction observed in pneumonia. Fever was absent in most of the patients or, when present, was usually not high and occurred at intervals.

The disease may continue for years. The first patient observed, though improved and able to work, still has symptoms. Of the other 26 patients studied, one has completely recovered and four others have shown definite improvement. Eight have died, some of these from complicating fungus infections of the lung. Neither corticoids nor antibiotics seem to affect the course of the illness. The disease evidently strikes about two and a half times as many males as females. Most victims are between 20 and 50 years of age, though there has been one 2-year-old boy patient and a man of 57.

National Academy Elections

Detlev W. Bronk, president of Rockefeller Institute, has been elected to a third 4-year term as president of the National Academy of Sciences. The election took place on 29 April during the 95th annual meeting of the academy at its headquarters in Washington, D.C. Also elected were Howard P. Robertson, professor of mathematical physics at the California Institute of Technology, Pasadena, Calif., as foreign secretary, and two new members of the council of the academy: Thomas F. Francis, Henry Sewall professor of epidemiology and chairman of the department, School of Public Health, University of Michigan; and Saunders MacLane, professor of mathematics, University of Chicago.

Retiring foreign secretary is John G. Kirkwood, Sterling professor and chairman of the department of chemistry, Yale University. Francis and MacLane will succeed E. A. Doisy, director of the department of biochemistry, St. Louis University School of Medicine, and Theophilus S. Painter, distinguished professor of zoology at the University of Texas. The new foreign secretary and council members will assume their new positions on 1 July 1958. The term of the foreign secretary runs for 4 years and that of the council members, for 3 years.

At the recent meeting the National Academy also announced the election of 30 new members. Election to membership in the academy is one of the highest honors which can be conferred upon an American scientist. It is interesting to note that approximately one-third of the new members—nine of them—are naturalized American citizens.

The new members are as follows: Emil Artin, Henry B. Fine professor of mathematics, Princeton University; Dietrich H. F. A. Bodenstein, insect physiologist, Medical Laboratories, Army Chemical Center, Md.; David Bodian, professor of anatomy, Johns Hopkins University; André Frederic Cournand, professor of medicine, Columbia University, and Nobel laureate in physiology and medicine, 1956; Martin Deutsch, professor of physics, Massachusetts Institute of Technology; John Holmes Dingle, professor of preventive medicine, Western Reserve University; Marshall DeMotte Gates, assistant editor of the *Journal of the American Chemical Society* in charge of organic and biological chemistry; Walther Frederick Goebel, member, Rockefeller Institute for Medical Research; Leo Goldberg, chairman of department of astronomy at the University of Michigan and director of the McMath–Hulbert Observatory; Maurice Goldhaber, senior physicist, Brookhaven National Laboratory; William Zev Hassid, professor of plant biochemistry and biochemist at the University of California; Charles Row Hauser, professor in organic chemistry, Duke University; Alfred Day Hershey, staff member, department of genetics, Carnegie Institution of Washington, Cold Spring Harbor, N.Y.; Robert Hofstadter, professor of physics, Stanford University; Izaak Maurits Kolthoff, professor and head of the division of analytical chemistry, University of Minnesota; Henry Arnold Lardy, professor of biochemistry, University of Wisconsin; Robert Eugene Marshak, Harris professor and chairman of department of physics, University of Rochester; Robert Reynolds McMath, professor of astronomy, University of Michigan; Robert Franklin Mehl, dean of graduate studies, Carnegie Institute of Technology; Neal Elgar Miller, Angell professor of psychology, Yale University; Frank Press, professor of geophysics, California Institute of Technology, and director, Seismological Laboratory; Alfred Clarence Redfield, associate director, Woods Hole Oceanographic Institution; Dickinson W. Richards, Jr., Lambert professor of medicine, Columbia University, and Nobel laureate in physiology and medicine, 1956; David Shemin, professor of biochemistry, Columbia University; Thomas Kilgore Sherwood, professor of chemical engineering, Massachusetts Institute of Technology; Llewellyn Hilleth Thomas, member of the senior staff, Watson Scientific Computing Laboratory of International Business Machines Corporation, and professor of physics, Columbia University; Oswald Garrison Villard, Jr., professor of electrical engineering, Stanford University, and director, Stanford Radio Propagation Laboratory; Chien-Shiung Wu, associate professor of physics, Columbia University; Hatten Schuyler Yoder, Jr., petrologist, Geophysical Laboratory, Carnegie Institution of Washington; and Bruno Hasbrouck Zimm, research scientist, General Electric Company.

The following were elected as foreign associates of the academy: Per Adolf Geijer, director, Geological Survey of Sweden, Stockholm; Hitoshi Kihara, professor of genetics, Kyoto Imperial University, and director, Kihara Institute for Biological Research, Kyoto, Japan; and Max von Laue, director, Fritz Haber Institute of Max Planck Society, Berlin, Germany.

Satellites Could Be Mistaken for Missiles

John P. Hagen, director of the Navy's Project Vanguard satellite program, said recently that there was a danger that satellites passing through space could be mistaken for incoming ballistic missiles, thus precipitating a global war. In testimony before the House Select Committee on Astronautics and Space Exploration, Hagen suggested that an international commission be established to set limitations on the objects put into space. He also asked for regulations to establish the identifying radio transmitters they should carry. He pointed out that it would take "very close observation" with radar detection devices to distinguish between a dead satellite passing overhead, an incoming intercontinental ballistic missile, and a stray meteor.

North Pacific Salmon

Biologists of the Bureau of Commercial Fisheries of the U.S. Fish and Wildlife Service at Seattle, Wash., left on 1 May in two chartered schooners to continue their effort to determine which North Pacific salmon are Asiatic and which are American. Investigators from the Pacific Salmon Investigations Laboratory will make a 4-month study that will cover the central North Pacific Ocean and much of the Bering Sea from 46° to 58° North Latitude and from the West Coast to 172° East Longitude, an area of about 1,500,000 square miles.

Also participating in the high-seas studies of salmon will be vessels of the Fisheries Institute of the University of Washington, the Fisheries Research Board of Canada, and the Fisheries

Agency of the Japanese Government. The work is being conducted under the International Convention for the High Seas Fisheries of the North Pacific Ocean, signed at Tokyo, Japan, 9 May 1952.

Serving as research agency for the United States Section of the International North Pacific Fisheries Commission, the investigators are trying to determine the home base of salmon taken on the high seas. Were these salmon spawned in American or Asiatic streams? In what areas do they mingle in the high seas? By what characteristics may the Asiatic and American fish be distinguished?

This is the fourth year of the salmon studies. Results of the 1958 studies will be presented at the next meeting of the International North Pacific Fisheries Commission, to be held in Tokyo in November 1958.

National Committee of History and Philosophy of Science

The United States Committee of the International Union of the History and Philosophy of Science has been established to effect appropriate United States participation in the International Union through the National Academy of Sciences–National Research Council, which adheres to the union on behalf of the historians and the philosophers of science in the United States. The first meeting of the committee was held in January at the National Academy.

The committee is composed of Marshall Clagett, Charles C. Gillespie, Henry Guerlac, C. Doris Hellman, and Conway Zirkle, representing the History of Science Society; C. J. Ducasse, Ernest Nagel, and Henry Margenau, representing the Philosophy of Science Association; Willard van Orman Quine and J. Barkley Rosser, representing the Association for Symbolic Logic. In addition, there are ex-officio voting members in their capacity as U.S. officers of international organizations; Alfred Tarski, president of the Division of the Philosophy of Science of IUHPS; Stephen C. Kleene, president of the Association for Symbolic Logic; and Philipp Frank, director of the Institute of the Unity of Science. Finally, there are three exofficio nonvoting members: Raymond J. Seeger, deputy assistant director of the National Science Foundation as liaison representative, and Wallace W. Atwood, Jr., and André C. Simonpietri, respectively director and associate director of the Office of International Relations of the National Academy of Sciences–National Research Council.

At the first meeting Nagel was nominated as chairman of the committee and Guerlac as vice-chairman. Hellman was appointed secretary. Three members-at-large were nominated: Percy Bridgman, Richard H. Shryock, and Carl B. Boyer. The respective appointments have been made by the president of the academy.

There are two permanent subcommittees of the National Committee, one on the History of Science and one on the Logic, Methodology and Philosophy of Science. Clagett was elected chairman of the former and Quine chairman and Margenau vice-chairman of the latter.

Radiocarbon Dates

The Committee for Distribution of Radiocarbon Dates was formed at the Conference on Radiocarbon Dating held in Andover, Mass., October 1956. The committee has created a service organization capable of (i) assembling all known radiocarbon dates, (ii) producing complete description of all dated samples on punched cards coded for sorting into universally useful categories, and (iii) distributing to subscribers this set of cards carrying complete information otherwise nearly impossible to assemble. The service organization plans to distribute some 5000 cards to each subscriber during the next 5 years, including about 3000 now available. The necessary coding and sorting equipment and index guides will be included.

However the committee must know how many sets of cards to prepare and how much cash from subscriptions may accrue to meet the expenses of production. Therefore, a questionnaire is being circulated. It is estimated that the total cost for 5000 cards will be about $250, provided a sufficient number subscribe. If only a few subscribe, the cost will be almost double this amount. For further information and a copy of the questionnaire, write to Frederick Johnson, R. S. Peabody Foundation, Box 71, Andover, Mass.

Grants, Fellowships, and Awards

Connective Tissue. The Helen Hay Whitney Foundation, which was originally established in 1947 to stimulate and support research in rheumatic heart disease, has announced its annual fellowship program. Any properly qualified person up to the age of 35, holding the M.D. or Ph.D. degree or the equivalent, who is seriously considering a career in biological or medical research, preferably relating in some way to connective tissue and its diseases, is eligible for consideration.

The applicant must have a commitment for adequate facilities and research expenses other than salary during the tenure of the fellowship from an institution or laboratory acceptable to the Scientific Advisory Committee. A contribution of $1000 will be made to the laboratory of the fellow selected.

Application forms should be requested from the Executive Secretary, Helen Hay Whitney Foundation, 525 E. 68 St., New York 21, N.Y. Applications should be mailed prior to 15 August for fellowships commencing 1 July of the following year.

In addition to the fellowship program, the foundation will select a small number of established investigators to be supported for a period of 5 years or more, such support to include salary and certain minimal research expenses. Preference will be given to past and present fellows of the foundation.

History of Science. An annual award of $250 has been established by Henry and Ida Schuman of New York City for an original prize essay in the history of science and its cultural influences. This competition is open to undergraduate and graduate students in any American or Canadian college, university, or institute of technology. Papers should be approximately 5000 words in length, exclusive of footnotes, and thoroughly documented. It is hoped that the prize-winning essay will be suitable for publication in *Isis,* the journal of the History of Science Society.

Papers may deal with the ideas and accomplishments of scientists in the past; they may trace the evolution of particular scientific concepts; or they may study the historical influences of one branch of science upon another. Essays dealing with medical subjects are not acceptable, although papers dealing with the relations between medicine and the natural sciences will be welcomed.

For further information, write to the Chairman of the Prize Committee, Prof. Raymond P. Stearns, 313 Lincoln Hall, University of Illinois, Urbana, Ill. Inquiries about the competition may also be addressed to Stearns. Papers must be received on or before 1 July.

Photobiology. Brandeis University has announced the establishment of 20 fellowships, made possible through a grant from the National Institutes of Health, to cover the costs of tuition, room, and board at the Institute of Photobiology that is to be held in Waltham, Mass., 23 June through 1 August. For further information, write to Brandeis University, Photobiology Institute, Waltham, Mass.

Public Health. Nominations for the sixth Kimble Methodology Research Award are being accepted until 1 June 1958. This award, which gives recognition to the application of scientific knowledge to the public health laboratory, was established by the Kimble Glass Company of Toledo, Ohio (subsidiary of the

Owens-Illinois Glass Company) and is sponsored by the Conference of State and Provincial Public Health Laboratory Directors. The cash award of $1000 and silver plaque will be presented at the annual meeting of the conference to be held in St. Louis, Mo., in November 1958. Rules governing nominations can be obtained from the chairman of the nominating committee: Dr. Nell Hollinger, School of Public Health, University of California, Berkeley 4, Calif.

History of Technology

In an effort to assess the impact of technology on society, a group of scholars has formed the Society for the History of Technology. The society will sponsor meetings at which various aspects of technological history will be investigated and will publish a quarterly journal, *Technology and Culture*. The Executive Committee of the newly formed society consists of the following members: chairman, Melvin Kranzberg, Case Institute of Technology; Carl W. Condit, Northwestern University; Howard Mumford Jones, Harvard University; Edward Lurie, University of Michigan; Robert Multhauf, Smithsonian Institution; William Fielding Ogburn, University of Chicago; Stanley Pargellis, Newberry Library; John B. Rae, Massachusetts Institute of Technology; Richard Shryock, Johns Hopkins University; and Lynn White, Jr., Mills College. An Advisory Council is also in the process of formation.

As its first program, the society will cosponsor the meeting of the Humanistic–Social Division of the American Society for Engineering Education, to be held at the University of California, Berkeley, 16–17 June. The society expects to begin publication of *Technology and Culture* in the fall of 1959. Applications for charter membership ($10) in the Society for the History of Technology should be sent to Prof. Melvin Kranzberg, Room 315, Main Building, Case Institute of Technology, Cleveland 6, Ohio.

Scientists in the News

The following awards were made during the American Chemical Society's 133rd national meeting, which took place in San Francisco last month: WILLIAM S. JOHNSON of the University of Wisconsin, the ACS Award for Creative Work in Synthetic Organic Chemistry, sponsored by the Synthetic Organic Chemical Manufacturers Association; JACOB BIGELEISEN of the Brookhaven National Laboratory, the ACS Award for Nuclear Applications in Chemistry, sponsored by the Nuclear–Chicago Corporation; DuBOIS EASTMAN of the Texas Company, the ACS Award in Industrial and Engineering Chemistry, sponsored by the Esso Research and Engineering Company; CARL DJERASSI of Wayne State University, the ACS Award in Pure Chemistry, sponsored by Alpha Chi Sigma fraternity; MAURICE F. HASLER of the Applied Research Laboratories, Beckman Award in Chemical Instrumentation; WILLIAM G. GORDON of the U.S. Department of Agriculture, Eastern Regional Research Laboratory, the Borden Award in the Chemistry of Milk; JAMES J. LINGANE of Harvard University, the Fisher Award in Analytical Chemistry; GEORGE BUCHI of Massachusetts Institute of Technology, the Fritzsche Award; ARDA ALDEN GREEN, deceased, of the Johns Hopkins University, the Garvan Medal; WILLIAM L. LAURENCE of the *New York Times*, the James T. Grady Award; PAUL H. EMMETT of the Johns Hopkins University, the Kendall Company Award in Colloid Chemistry; LESTER J. REED of the University of Texas, the Eli Lilly and Company Award in Biological Chemistry; EUGENE P. KENNEDY of the University of Chicago, the Paul–Lewis Laboratories Award in Enzyme Chemistry; ROBERT P. EISCHENS of the Texas Company, the Precision Scientific Company Award in Petroleum Chemistry; ERNEST H. VOLWILER of the Abbott Laboratories, the Priestley Medal; FRANK E. BROWN of Iowa State College, the Scientific Apparatus Makers Award in Chemical Education.

Recent appointments in fundamental research at the Mellon Institute, Pittsburgh, Pa., include: staff fellow, A. A. BOTHNER-BY of Harvard University; senior fellow, M. H. J. WIJNEN of the University of Louvain; and the following fellows, E. G. ERDÖS of Ludwig Maximilian University, CECILE C. NAAR of Brussels University, J. G. PRITCHARD of University College (London), D. R. SEARS of Cornell University, and F. WENGER of the University of Bern.

Personnel added to contractual research projects of the institute are as follows: senior fellow, B. A. McALEER of the University of Pittsburgh; and fellows, S. Z. BEER of Polytechnic Institute of Brooklyn, G. K. BHAT of Lehigh University, and L. J. KROKO of Carnegie Institute of Technology.

HAROLD E. YOUNG, associate professor of forestry at the University of Maine, has been granted a year's leave of absence in order to serve as a civilian scientist with the Operations Analysis Office of the North American Air Defense Command in Colorado Springs, Colo. He will begin his duties on 1 September.

EUGENE S. TURRELL, associate professor of psychiatry at the University of Colorado School of Medicine, has been appointed medical director of the Milwaukee Sanitarium Foundation and professor of psychiatry at Marquette University School of Medicine, effective 1 July.

WARREN S. WOOSTER has returned to the Scripps Institution of Oceanography, La Jolla, Calif., as associate research oceanographer. During the past year he has been director of investigations for the Peruvian Council of Hydrobiological Investigations in Lima.

CHARLES S. REDDING, board chairman, Leeds & Northrup Company, Philadelphia, has received the Scientific Apparatus Makers Award for "highest achievement in developing the industry's capacity for serving the nation in the fields of industry, research, education, health and defense."

H. W. LASER, of the British Medical Research Council's external staff, working at the Molteno Institute of Biology and Parasitology in Cambridge, England, will be at the Argonne Laboratory, Lamont, Ill., for 6 months, beginning in July. He will investigate the use of tissue cultures for determining radiation effects.

IRA KUKIN, specialist in colloidal chemistry, has been appointed research director of the Belleville (N.J.) Research Center of L. Sonneborn Sons, Inc. He succeeds the late Abraham Moscowitz, who died in February. Kukin was formerly on the staff of the Gulf Research and Development Company, where for 6 years he was in charge of fundamental research in the product division.

JEAN P. ROSSELET has been appointed senior biochemist in the biochemistry department of the Schering Corporation, Bloomfield, N.J. Prior to joining Schering, Rosselet was with another pharmaceutical manufacturer and also was a research associate at Columbia University.

EVERETT R. HOLLES, formerly with the U.S. Atomic Energy Commission, has joined the General Atomic Division of General Dynamics Corporation, San Diego, Calif., as assistant to Frederic de Hoffmann, a vice president of the corporation and division general manager of General Atomic. Holles, who was assistant to Lewis L. Strauss, chairman of the AEC, has had extensive experience as a news correspondent and

radio-television commentator in this country and abroad during the past 25 years.

HAROLD E. ANTHONY, chairman of the department of mammals at the American Museum of Natural History, has retired after 47 years of service. Anthony joined the staff in the spring of 1911 as a naturalist with an expedition off the coast of Lower California. He was made an associate curator in the mammal department in 1919, a full curator in 1926, and has held the chairmanship of the department since 1942. From 1942 to 1947 he served as dean of the Scientific Council, and he was the museum's deputy director from 1952 until the fall of 1957.

A specialist in the mammals of the Western Hemisphere, Anthony has done extensive research on extinct mammals of the West Indies. Participating in a project to determine the geological origins of the islands, he collected the fossil remains of many species no longer in existence in order to compare them with forms still living on the mainlands of the American continents. As part of his research he has led major expeditions to most of the countries of South and Central America, has participated in expeditions to Africa and Burma, and has directed considerable field work in the western United States and Alaska. Anthony's writings include *Mammals of Puerto Rico,* published in two volumes in 1925 and 1926; *Field Book of North American Mammals,* 1928; and many short papers on systematics of mammals.

The museum's board of trustees has appointed Anthony curator emeritus of mammals, effective immediately, and on his return from a trip to the West Coast he will be curator of the Frick Laboratory, a research laboratory located at the museum and maintained by the Childs Frick Foundation for the study of fossil life.

LOUIS H. RODDIS, Jr., deputy director of the Atomic Energy Commission's Division of Reactor Development, has resigned, effective about 15 July, to become president of the Pennsylvania Electric Company of Johnstown, Pa., a subsidiary of the General Public Utilities Corporation. Roddis has been a member of the AEC Reactor Development Division since its inception in February 1949.

STUART C. CULLEN, professor of surgery and anesthesiology at the State University of Iowa College of Medicine, has been appointed professor of anesthesia and chairman of the department in the University of California School of Medicine, San Francisco, effective 1 July. Among Cullen's research interests have been the use of curare and other muscle relaxants in anesthesia; the effects of drugs on respiratory function; the gas content of blood under varying conditions; and the physiological effects of xenon and other inert gases.

JOSEPH V. SWINTOSKY, a research group leader at Smith, Kline & French Laboratories, Philadelphia, has received the Ebert Prize of the American Pharmaceutical Association, the highest scientific award in American pharmacy. The prize is given annually for the best original research paper published in the journals of the American Pharmaceutical Association. Swintosky was the senior author of two papers, the beginning of a series, on studies dealing with quantitative measurement of absorption, distribution, and excretion of a sulfonamide (sulfaethidole) after oral and intravenous administration.

ARTHUR S. DETER, a technical writer for the Scintilla Division of the Bendix Aviation Corporation, has been named senior editor of the Scientific Information Division of Eaton Laboratories, Norwich, N.Y.

EARLE C. GREGG, formerly associate professor of physics at Case Institute of Technology, is now associate professor of radiology (radiation physics) at Western Reserve University School of Medicine.

Recent Deaths

OTTO BARKAN, San Francisco, Calif.; 71; eye specialist who discovered a surgical treatment for glaucoma; devised a new system of classification and surgical diagnosis of eye diseases; in his 37 years of practice contributed more than 60 articles to American and foreign medical journals in his field; 26 Apr.

MARGERY FRY, London, England; 84; penologist and advocate of prison reforms; specialist in juvenile delinquency; principal of Somerville College, Oxford University, 1926–31 and Governor of the British Broadcasting Corporation, 1937–39; author of *Arms of the Law*; 21 Apr.

RICHARD B. GOLDSCHMIDT, San Francisco, Calif.; 80; professor emeritus of zoology, University of California; geneticist; head of the Kaiser Wilhelm Institute for Biological Research, 1921–36; conducted research on sex determination and on evolution, embryology, and physiological genetics; 24 Apr.

EUGENE GUSTAFSON, Chicago, Ill.; 52; vice president in charge of engineering for the Zenith Radio Corporation; 24 Apr.

ROBERT H. HENDERSON, East Orange, N.J.; 81; engineer and retired owner of the Henderson Electric Company; holder of 14 patents; 22 Apr.

WALTER H. MAGILL, Philadelphia, Pa.; 79; professor emeritus of education at the University of Pennsylvania; author of many books and pamphlets in the field of teacher training; 21 Apr.

I. WILLIAM NACHLAS, Baltimore, Md.; 63; associate professor of orthopedic surgery at Johns Hopkins Medical School; one of the first to use penicillin and other antibiotics for osteomyelitis and other bone infections and also one of the first to use metal staples for strengthening the spine; orthopedic chief at Sinai Hospital, Baltimore, and at the Levindale Home for Incurables; 20 Apr.

GEOFFREY W. RAKE, Princeton, N.J.; 53; scientific director of the international division of the Olin Mathieson Chemical Corporation; research professor of microbiology at the University of Pennsylvania; chairman of the research and grants committee of the New York Cancer Committee; performed research on virus diseases and tuberculosis, about which he wrote more than 150 articles; 20 Apr.

JOHN S. RODMAN, Radnor, Pa.; 74; emeritus professor of surgery at Woman's Medical College, Philadelphia, and former chief surgeon of Woman's Medical College Hospital; founder-member and secretary-treasurer of the American Board of Surgery in 1937; former president of the Philadelphia Academy of Surgery; 26 Apr.

CARL R. SCHROEDER, Short Hills, N.J.; 68; consulting engineer for the Metals and Thermit Corporation, New York; 22 Apr.

JOHN N. SELVIG, Westfield, N.J.; 80; before retirement, mechanical engineer with the Western Electric Company in Kearny, N.J., for 33 years; 20 Apr.

GEORGE V. SLOTTMAN, New York, N.Y.; 54; vice president for research and engineering of the Air Reduction Company; contributed to the technology of carbides, acetylene, and oxygen; 21 Apr.

BURNETT SMITH, Skaneateles, N.Y.; 81; geologist and paleontologist; professor of paleontology at Syracuse University for 21 years; temporary geologist, New York State Museum, 1926–39; president of the Paleontological Research Institution, 1937–39; 31 Mar.

JAMES D. VERPLANCK, Rhinebeck, N.Y.; 87; retired in 1930 as a research worker for the U.S. Bureau of Standards in Washington; wrote articles on the American Indians; 23 Apr.

GALE H. WALKER, Polk, Pa.; 52; superintendent of the Polk State School, an institution for retarded children, and a specialist in mental hospitals; past president of the Association of Mental Deficiency; published many articles on mental retardation in children; 22 Apr.

Book Reviews

Science and Human Values. J. Bronowski. Julian Messner, Inc., New York, 1956. 94 pp. $3.

Novels, histories, music, and paintings make it a pleasure for a worker in science to follow the humanities. Rarely are the human values of science presented with equal mastery and charm. Let the reader who believes in those values give a copy of this 94-page book to his nonspecialist friend. His gift will be gratefully acknowledged, and not only for the beautiful pictures, of which three come from William Blake and two from Leonardo da Vinci. Bronowski carries us far away from all the familiar talk of science and faster planes, cheaper electricity, and more creature comforts—talk all right as far as it goes, but so dismaying because it says no more. With rich allusions to science, literature, art, and human experience, Bronowski urges that science, if it can transmit its spirit to the world, will contribute even more to mankind than it can by all its discoveries.

Bronowski leads up to his central thesis step by step in the three sections of this book: (i) "The Creative Mind," (ii) "The Habit of Truth," (iii) "The Sense of Human Dignity." The factors making for creativity have been more fully treated in other places but perhaps nowhere with a broader range of allusion. His mention of Coleridge recalls the advice of Arthur D. Little to an industrialist wanting advice on how to set up a forward-looking research laboratory: "Read John Livingstone Lowe's *The Road to Xanadu!*"

How shall one assess the book? First, it states in a clear way the much needed message that science is an activity in which every human being can engage, not a cult practised by a sacred priesthood. Second, Bronowski makes a strong case for one simple thesis: To have a forward-moving human community in these days, general participation in the search for truth is a spiritual necessity. May he be widely read! He says we have not too much science today but too little: "the scientific spirit is more human than the machinery of governments. We have not let either the tolerance or the empiricism of science enter the parochial rules by which we still try to prescribe the behavior of nations." Finally, one can agree wholeheartedly with Bronowski that the search for truth is a necessity without accepting the implication that it is also sufficient by itself to achieve the world we want. Here the science-minded citizen will want to add some comments of his own. The culture of Greece was necessary for its greatness but not sufficient for its survival. The search for truth can flourish in a society strong enough to protect freedom, but to protect that freedom it is not enough only to search for the truth. The prime requirement is the survival of the free world. Rather than see it fall with its centuries-old heritage, more precious than any individual life, many would choose to join with dear friends, as others have in past ages, to give up their own lives. About self-sacrifice, kindliness, courage, and nobility, about how the highest human virtues were won for our race by millenia of struggle for survival, Bronowski says nothing. Nothing does he tell of the revolutionary and inspiring truths about man's origin and destiny to be read from the work of Darwin and his successors. How can one discuss science and human values without facing up to human evolution? But let Bronowski not be condemned for what he overlooks but praised for what he brings us: poetic insight into one aspect of evolution in this quotation from William Blake: "to be an Error & to be Cast out is a part of God's design." The reader of this charming book has much on which to meditate.

JOHN WHEELER
Department of Physics, Princeton University

The Life, Work and Times of Charles Turner Thackrah, Surgeon and Apothecary of Leeds (1795–1833). A. Meiklejohn. Livingstone, Edinburgh, Scotland, 1957 (distributed by Williams & Wilkins, Baltimore, Md.). 238 pp. $6.

The industrial revolution in England brought forward a number of able investigators on the many phases of occupational hazards, and none more able than Charles Thackrah of Leeds. Bernardino Ramazzini (1633–1714), with his *De morbis artificium diatriba* (Modena, 1700), became the father of industrial medicine, and many followed his lead with individual contributions to the subject, but it remained for Thackrah to extend primitive clinical observations into a comprehensive conception of industrial health based upon prevention and thus to become the founder of industrial hygiene. Charles Thackrah's views were first published in 1831 and became influential in initiating factory reforms.

The volume under review is a facsimile of the second edition (1832) of Charles Thackrah's principal work (the short title of which is *The Effects of Arts, Trades, and Professions*), supported by an excellent and informative biographical essay on Thackrah. Thackrah's principal publication has become rare. It "claims our attention not for its knowledge but for its wisdom." The author has made this wisdom readily available to all students of industrial medicine and hygiene who care to dip into this fountain.

J. B. DEC. M. SAUNDERS
University of California School of Medicine, San Francisco

The Mango. S. R. Gangolly, Ranjit Singh, S. L. Katyal, and Daljit Singh. Indian Council of Agricultural Research, New Delhi, India, 1957. xiii + 530 pp. Illus. $12.

The mango is by far the most important fruit crop of India; approximately 1.5 million acres were in cultivation in 1955. It is estimated that there may be a thousand varieties, although the nomenclature is badly confused and the same mango is often known by different names in different regions. This book is devoted chiefly to eliminating some of this confusion by descriptions of 210 of the more important varieties; with each there is a very adequate color plate and a careful morphological description of the tree, leaves, inflorescence, fruit, stone, and quality of fruit. Actually, the descriptions of tree and leaf would not be very reliable guides in themselves for identification of variety, but the descriptions of fruit are very complete and distinct, and each morphological term used is carefully pictured. Most of the Indian varieties have green or yellow skins or a slight peach-colored blush. Only a few of the more than 200 varieties pictured have the attractive red blush considered essential in the United States for good marketability. The descriptions of variety, while of great usefulness in India, would be of only academic interest in most other mango-growing areas, since few of the Indian varieties are grown

elsewhere, due to their poor color and scanty yield. The key for descriptions of variety, however, might well be adopted by all who attempt to describe varieties of mango.

A brief chapter on the botany and cytogenics of the mango is well done. The balance of this volume (about 40 pages) is devoted to cultivation and to insect pests and diseases. In centuries past, Indian princes used to pride themselves on the possession of exclusive varieties and on large mango gardens. Akbar, the great Mughal Emperor, is said to have had a garden of 100,000 trees. These were chiefly, if not entirely, seedling trees, whereas most plantings now are vegetatively propagated. The book gives considerable detail on methods of vegetative propagation and of top-working, little of which is not well known to mango growers everywhere. Planting, irrigation, and manuring (fertilization) practices are discussed and serve to point up the fact that very little of an exact nature is known regarding the culture of this fruit, despite its antiquity. Irregular bearing of most varieties is a problem in India, as in other areas where mangos are grown. The insect pests and diseases of the mango in India are well presented; in each case the scientific name, the nature of the injury, and the control measures are given. A comprehensive bibliography of 162 citations is useful and also indicates that the authors are cognizant of such scientific work as has been done with this fruit.

FRANK E. GARDNER
U.S. Department of Agriculture, Orlando, Florida

A Pictorial History of Science and Engineering. The story of man's technological and scientific progress from the dawn of history to the present, told in 1,000 pictures and 75,000 words. By the editors of *Year*. *Year*, New York, 1958. 263 pp. Illus. $7.95.

The lack of an adequate, brief, and popular history of modern science leaves unsatisfied an obvious demand which must seek its fulfillment in highly specialized works or in "picture histories" such as this. The editors of *Year* have endeavored to be up to date, even touching—the word should be emphasized—on automation and the Russian satellite. They have also done more justice than might have been expected to the science of antiquity and the other benighted centuries before modern times.

The topical subdivision is well conceived, and the narrative on the centuries up through the eighteenth is excellent, showing commendable concern for accuracy. The 19th and 20th centuries, however, seem to have been the editors' undoing, as they have been the undoing of others who have attempted to deal with them historically. The text here tends increasingly to vagueness—a vagueness liberally salted with names of inventors and inventions.

Many of the illustrations are interesting, but few are spectacular and many are very ordinary. On the whole, the selection of pictures is only fair, and the effectiveness of those that are included is badly marred by the editors' failure to identify them adequately; the reader is thus left free to suppose, for example, that some primordial photographer caught the cave men painting mammoths (page 16). Something more than the technical picture credits would certainly have been in order.

Its determined up-to-dateness will probably lead potential readers to regard the book as being out-of-date next year. This is a pity, for the first part, at least, deserves a longer life. When all is said and done, however, one can hardly expect to learn much more of the history of science from such a book than one could learn of physics from a picture history of that subject.

ROBERT P. MULTHAUF
Department of Science and Technology, Smithsonian Institution

Animal Behavior. John Paul Scott. University of Chicago Press, 1958. xi + 281 pp. Illus. $5.

No part in biology is more beset with the pitfalls of scientific methodology than is the study of animal behavior. The subject is intrinsically difficult—dealing, as it does, with the integrated totality of organisms—but because of its familiarity, it seems deceptively simple. Everyone has observed animals at one time or another and formed opinions about what they were doing. Putting these thoughts to paper, however, should quickly reveal that comparative psychology is no place for an amateur. John Paul Scott is a long-time professional in the field, and his book shows the wide range of his experience and knowledge. He has, however, attempted the perhaps impossible task of writing a book meant to serve both as a text and as an introductory account for the nonspecialized reader. Although he has produced the best general introduction to the subject we have ever had—one that can be read with profit by student and layman alike—his treatment lacks the emphasis on aspects of logic necessary to make it a satisfactory text. I should add that, in my opinion, there is *no* satisfactory up-to-date textbook on comparative psychology or animal behavior in existence today.

The study of animal behavior is in a protean condition; the serious student should be informed of this challenging state of affairs. The present volume, however, has little to say about the different points of view on fundamental questions currently under debate. In addition, making such topics as agonistic and allelomimetic behavior, learning, intelligence, and language the primary points of reference, rather than the various phylogenetic groups of animals, tends to encourage looseness of thought. As Scott himself puts it (although in a different context), "What words can we use to say that two animals as unlike as elephants and spiders are doing similar things?" The problem of finding criteria for meaningful similarities among divergent animal forms is one of the knottiest in comparative psychology.

Attention should be called to the fine illustrations, both drawings and photographs, that enliven and enhance this book.

JAMES W. ATZ
New York Aquarium, New York Zoological Society

The Beginnings of Embryonic Development. A Symposium organized by the Section on Zoological Sciences of the American Association for the Advancement of Science, cosponsored by the American Society of Zoologists and the Association of Southeastern Biologists, and presented at the Atlanta meeting, December 27, 1955. Publication No. 48. Albert Tyler, R. C. von Borstel, Charles B. Metz, Eds. American Association for the Advancement of Science, Washington, D.C., 1957. 400 pp. Illus. $7.50, members; $8.75, others.

This volume includes the papers presented at a symposium organized by the Section on Zoological Sciences of the American Association for the Advancement of Science at the Atlanta meeting, 27 December 1955, as well as several chapters, contributed by other embryologists, which are intended to expand the coverage of this general field.

The book begins with an important chapter by W. S. Vincent on a relatively neglected area to which new techniques have been applied in recent years—namely, the differentiation and development of the oocyte, with particular emphasis on the role of the nucleus. The author comes to the conclusion that the nuclear ribonucleic acid molecules are carriers of structural specificity imparted by genetic loci and transferred to the cytoplasm. C. B. Metz discusses the role played by the interaction of specific egg and sperm substances in the fertilization and activation of the egg. While substances such as egg membrane lysin, fertilizin, and antifertilizin are apparently

essential for the approach and initial union of the gametes, evidence for a direct role of these substances in the primary activation reaction is wanting.

The two chapters that follow deal with fertilization in mammals. C. R. Austin and M. W. H. Bishop analyze the highly specialized internal environment in which fertilization takes place. Many integrated processes and reactions ensure the meeting of the gametes in appropriate numerical relations and at the optimal phase of their life-cycle. However, different species of mammals exhibit wide variations in the details of these mechanisms. M. C. Chang deals with the physiological changes at sperm penetration, activation, and syngamy and points out the great gaps in our knowledge of these processes and of the physiology of the Fallopian tube, the corona radiata, the zona pellucida, and the vitelline membrane. Results obtained with marine eggs may not be applied to mammalian fertilization at present.

A. L. and L. H. Colwin contribute a lucid summary of their researches on the importance of the acrosome filament in the initial contact between sperm and egg in echinoderms, molluscs, annelids, and enteropneusts. In spite of these important discoveries, the mechanism of the subsequent movement of the sperm into the egg is still not known. A brief section on changes in proteins of the sea urchin egg following fertilization, by A. Monroy, is followed by an excellent review of nucleocytoplasmic relations in early insect development, by R. C. von Borstel, where the destruction of three of the four nuclei resulting from meiosis in the egg, and the inhibition of the accessory sperms, offer special and intriguing problems. The occurrence of photoreactivation of ultraviolet radiation damage following irradiation of the nucleus, and the absence of such photoreactivation when the egg cytoplasm is irradiated, may make it possible to distinguish between action of the nucleus and action of the cytoplasm in the causation of an embryonic event.

H. E. Lehman summarizes the evidence for nuclear differentiation during development, particularly the results obtained with nuclear transplantation in amphibian eggs, and concludes that progressive nuclear differentiation, presumably imposed upon the nucleus by the cytoplasm surrounding it, must be admitted at least as a possibility.

In the section entitled "Morphogenesis and metabolism of gastrula-arrested embryos in the hybrid *Rana pipiens* × *Rana sylvatica*," J. R. Gregg describes the peculiar biochemical features of hybrid embryos, one of which is the lowered rate of energy liberation from glycolytic processes. Unfortunately, it cannot yet be decided whether this biochemical deficiency is the cause of the arrest of development or is itself a parallel effect of the hybrid constitution of the embryo.

J. R. Shaver discusses the possible role of cytoplasmic particles, particularly of mitochondria, in differentiation. He is critical of attempts to explain differentiation on the basis of ordered distribution patterns of mitochondria, whose existence has not been demonstrated beyond doubt.

Under the uninformative title of "Early determination in development under normal and experimental conditions," S. Ranzi presents evidence that, in the sea urchin egg, fertilization activates certain enzyme systems at the animal pole and that the resulting metabolites lead to development of this area in the animal direction.

G. Reverberi presents an admirable summary of the role of some enzymes in the development of ascidians and other animals, studied by means of cytochemical methods and specific inhibitors. He concludes that there is "reasonable probability" that some enzymes play a role in morphogenesis of "mosaic" eggs, while the evidence for "regulative" eggs is less convincing.

The volume concludes with a chapter on "Immunological studies of early development," by A. Tyler, in which the author reviews recent studies on the detection in the embryo of specific antigens to adult tissues, on the development of antibody-forming capacity, and on the effects of antibodies on development. He relates the results to his well-known auto-antibody concept.

The book as a whole contains a wealth of facts and hypotheses on various important aspects of the beginnings of development, which the reader is left free to evaluate and coordinate. I could not avoid having the strong impression that, at this time, it is still impossible to prove the causation of any process of differentiation by biochemical events, and that no new avenues of approach have opened up which would lead to crucial evidence in the near future.

G. FANKHAUSER
Department of Biology,
Princeton University

Electron Impact Phenomena. And the properties of gaseous ions. G. H. Field and J. L. Franklin. Academic Press, New York, 1957. ix + 349 pp. Illus. $8.50.

Important to physical chemists and chemical engineers is the identification of molecules and molecular fragments that follow reactions with catalitic agents, breakdown in intense heat, or dissociation under electron bombardment. The modern commercial mass spectrograph is one of the most important tools at the disposal of the physicist and the chemist for making identifications, and yet the results may not always be unambiguous. It is one of the purposes of this book to discuss, in a critical manner, experiments and experimental techniques that yield data on electron impact phenomena that may help in the interpretation of research investigations of interest to physical chemists in general and physical organic chemists in particular.

The organization of the book follows a logical procedure. First the apparatus and methods are discussed. Then there is a brief discussion of theory, followed by an extensive treatment under the heading "Energetic considerations." These sections constitute approximately one-half of the book and are written in a manner that I consider very effective. Even though there is a minimum of equations and technical description, the subjects discussed are presented concisely and critically. Over 500 references to original researches are given, and the organization of these alphabetically by author at the end of the book is to be commended. The fact that there is a good "name index" and "subject index" permits the reader not only to use the book as an effective reference source but also to locate the sections containing critical evaluation.

Not only will the reader find interesting text; the book contains a vast compilation of numerical data in tabular form, such as critical potentials applicable to many molecules, organic and inorganic. Associated with these data are excellent references, so that the user can evaluate for himself the experimental details on the basis of which the numerical values were determined.

This book will serve as an excellent reference book, useful to both physicists and chemists, and represents an important contribution to the literature.

WAYNE B. NOTTINGHAM
Research Laboratory of Electronics,
Massachusetts Institute of Technology

Behavioral Goals of General Education in High School. Will French and associates. Russell Sage Foundation, New York, 1957. 247 pp. $4.

The Russell Sage Foundation, The National Association of Secondary School Principals, and the Educational Testing Service, feeling that all learning is evidenced by changes in reactions, have jointly sponsored a volume on behavioral goals for general education in high schools and have organized these under three "maturity goals" and four "areas of behavioral competence." The first two parts of the book discuss the following topics: first, the history, purposes, nature, evidence, and scope of

general education; and second, the methods of using the present compilation to improve such general education. Then the major part of the book (122 pages) lists these goals as actions (for example, "uses the typewriter or writes well enough to meet his needs"). Listings of the general behaviors are followed not only by long lists of such illustrative, or more specific, behaviors but also by lists of "developmental equivalents" which are expected of younger or less mature students.

This is a remarkably useful collection that discusses more specific goals than most teachers have ever been asked to formulate for themselves. An honest appraisal of any high-school curriculum against these criteria will be both revealing and rewarding. The greatest danger is that a faculty may become so fascinated that it accepts *general education* as equivalent to all of education, and *behavioral goals* as the only goals of learning. Some goals may be more in the mind than evident in behavior.

In the book there is a fairly specific denial of the possibility that knowledge can be of value for its own sake and an apparent unawareness that some goals now unexpressed or even unrecognized might occur to a person of imagination as a result of his having acquired much knowledge of a subject in which he was informed and interested. It seems far too optimistic to expect all the troubles in schools to disappear if the schools could but become "behavioral-centered." Perhaps science and mathematics overlap general education less than some other subjects do, and learning in these areas is less often reflected in obviously overt behavior. For all areas of knowledge, however, it is profitable to state our purposes as specifically as possible, and this book supplies a generous number of thoughtfully formulated goals.

HENRY W. SYER

Boston University

New Books

Diseases of Tobacco. George B. Lucas. Scarecrow Press, New York, 1958. 506 pp. $10.

The Evil Eye. Edward S. Gifford, Jr. Macmillan, New York, 1958. 216 pp. $4.95.

Chemical Aspects of Ecology in Relation to Agriculture. Research Monogr. 1, Publ. 1015. Hubert Martin. Science Service Laboratory, Canada Department of Agriculture, Ottawa, 1958. 96 pp. $3.

Proceedings of the Rehovoth Conference on Nuclear Structure. Held at the Weizmann Institute of Science, Rehovoth, 8–14 Sept. 1957, under the auspices of the International Union of Pure and Applied Physics. H. J. Lipkin, Ed. North-Holland, Amsterdam; Interscience, New York, 1958. 630 pp. $12.50.

Infrared Absorption Spectra of Steroids. An atlas. vol. II. Glyn Roberts, Beatrice S. Gallagher, R. Norman Jones. Interscience, New York, 1958. 103 pp. and charts 309–760. $20.

The Role of Solid State Phenomena in Electric Circuits. Proceedings of the symposium sponsored by Polytechnic Institute of Brooklyn, Microwave Research Institute. vol. 7. Interscience, New York, 1957. 356 pp. $5.

Analytic Geometry. Edwin J. Purcell. Appleton-Century-Crofts, New York, 1958. 299 pp. $4.50.

Year Book of the Royal Society of London, 1958. Royal Society of London, London, 1958. 367 pp.

The Planet Jupiter. Bertrand M. Peek. Macmillan, New York, 1958. 283 pp. $8.50.

Gaseous Conductors. Theory and engineering applications. James Dillon Cobine. Dover, New York, rev. ed. 1, 1958. 625 pp. $2.75.

Figurets. More fun with figures. J. A. H. Hunter. Oxford University Press, New York, 1958. 127 pp. $3.50.

Colorimetric Determination of Nonmetals. David F. Boltz, Ed. Interscience, New York, 1958. 384 pp. $8.50.

Gas Dynamics. Ali Bulent Cambel and Burgess H. Jennings. McGraw-Hill, New York, 1958. 428 pp. $11.

Population Studies: Animal Ecology and Demography. Cold Spring Harbor Symposia on Quantitative Biology and Demography, vol. XXII. Biological Laboratory, Cold Spring Harbor, N.Y., 1957. 451 pp. $8.

Control of the Plant Environment. Proceedings of the University of Nottingham Fourth Easter School in Agricultural Science, 1957. J. P. Hudson, Ed. Academic Press, New York; Butterworths, London, 1957. 256 pp. $7.50.

Quantum Mechanics of One- and Two-Electron Atoms. Hans A. Bethe and Edwin E. Salpeter. Academic Press, New York; Springer, Berlin, 1957. 376 pp. $10.

Proceedings of the Fourth International Conference on Soil Mechanics and Foundation Engineering. London, 12–24 Aug. 1957. vols. 1 and 2 (vol. 3 in press). Butterworths, London, 1957 (order from Interscience, New York). 466 pp.; 467 pp. $79.50 for 3 volumes.

Connective Tissue. A symposium organized by the Council for International Organizations of Medical Sciences. R. E. Tunbridge, Madeline Keech, J. F. Delafresnaye, G. C. Wood, Eds. Thomas, Springfield, Ill., 1957. 371 pp. $8.50.

Introductory Plant Science. Henry T. Northen. Ronald, New York, ed. 2, 1958. 730 pp. $6.75.

The Impact of the Antibiotics on Medicine and Society. Monogr. II, Institute of Social and Historical Medicine. Iago Galdston, Ed. International Universities Press, New York, 1958. 232 pp. $5.

Tuberculosis in White and Negro Children. vol. I, *The Roentgenologic Aspects of the Harriet Lane Study,* Janet B. Hardy, 122 pp., $7.50; vol II, *The Epidemiologic Aspects of the Harriet Lane Study,* Miriam E. Brailey, 103 pp., $4.50. Harvard Univ. Press (for the Commonwealth Fund), Cambridge, Mass., 1958.

Miscellaneous Publications

(Inquiries concerning these publications should be addressed, not to Science, *but to the publisher or agency sponsoring the publication.)*

Decennial Review Conference on Tissue Culture, Proceedings. Woodstock, Vt., 8–12 Oct. 1956. Philip R. White. National Institutes of Health, Bethesda, Md. (reprinted from *J. Natl. Cancer Inst.* vol. 19, No. 4; (order from Philip R. White, Jackson Laboratory, Bar Harbor, Me.). 377 pp. $4.

Measurement of Air Pollution. Recommended methods for deposited matter, smoke, and sulphur dioxide. Department of Scientific and Industrial Research, London, 1957. 28 pp. 2s.

Radium-Isodosen. Die radiumdosierung in „r". August Verhagen. Thieme, Stuttgart, 1958. 102 pp. $4.65.

Civil Air Regulations and Flight Standards for Pilots. Associated Aeronautical Staff. Aero, Los Angeles, ed. 19, 1958. 96 pp. and supplements.

Central Wyoming Phosphate Rock. Character, processing and economics. Bull. No. 6. Walter E. Duncan and H. G. Fisk. Natural Resources Research Institute, University of Wyoming, Laramie, 1957. 60 pp.

Workbook for Field Biology and Ecology. Allen H. Benton and William E. Werner, Jr. Burgess, Minneapolis, 1957. 268 pp. $2.75.

Manual of Mammalogy. E. Lendell Cockrum. Burgess, Minneapolis, 1955. 160 pp. $4.

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Reports

Patterns of Tolerance to Lysergic Acid Diethylamide and Mescaline in Rats

D-Lysergic acid diethylamide (LSD-25) and mescaline are chemically distinct agents which induce similar alterations of psychological and autonomic function in man. Nonpsychotic human beings clearly develop tolerance to the behavioral and most of the autonomic effects of LSD-25 (*1, 2*), but mescaline has not been thoroughly studied in these respects. To our knowledge, the details of tolerance to the behavioral effects of LSD-25 and mescaline in rats have not been reported. Future investigation of neurochemical mechanisms underlying both tolerance and the action of psychosomimetic agents would be facilitated if patterns of tolerance could be delineated for two such agents in a single animal system. On the basis of findings discussed here (*3*), we report tolerance to the behavioral impairments due to LSD-25 and mescaline in the rat and the absence of tolerance to LSD-25-induced bradycardia.

In single-dose experiments, Winter and Flataker (*4*) found that LSD-25 impaired the performance of rats that had been trained to climb a rope; climbing time increased as a linear function of the logarithm of the dose. The method is not suitable for refined analysis of behavioral mechanisms, but it does quantitatively reflect the effects of dose on the complex of perceptual, motor, and coordinative functions necessary for efficient climbing. We thought that any increase in climbing time due to the drug would gradually disappear if tolerance to the drug were induced by daily injections. The rat, placed in the arena, is taught to grasp and climb a rope which extends 160 cm to a platform. We used neither electric shock nor noise as reinforcement but always gave food for the rat to eat or hoard at the end of a climb. Trained for 19 days, with prior food deprivation for the first 5 days, the rat establishes a stable climbing time, usually after 6 or 7 days. It maintains this stable time for months thereafter, often without specific intervening practice; these stable control times are not affected by placebo injection or satiety. Using male Sherman rats, 180 to 200 g in weight, we encountered occasional aversive reactions which seemed contingent specifically upon repeated intraperitonal drug injections; therefore, all trained animals received three intraperitoneal placebo injections at 48-hour intervals prior to initial drug injections, and during each injection they were fed a pellet. With each drug test group (A, B, and C) there was a placebo group. Failure to begin to climb from the arena within 60 seconds was scored as complete impairment; tests were run at regular intervals after each injection (Fig. 1).

Seven rats (group A) that were given daily intraperitoneal injections of 130 μg of LSD-25 per kilogram showed virtually complete tolerance in 4 days (Fig. 1). It is important to note that the gross behavioral effects of the drug (for example, piloerection, nonresponsiveness to approach, confusion, and "spontaneous distractibility") correlate with scored results. Development of tolerance is rapid, appearing in some animals as early as 1 day after the initial injection and in all animals by 4 days; tolerance can be maintained thereafter by daily injection. Findings were similar when the daily dose was increased, over 4 days, from 130 to 260 μg/kg.

A second group (B) of six rats received intraperitoneal injections of 130 μg of LSD-25 per kilogram at 48-hour intervals over a period of 14 days and displayed variability in the development of tolerance. One rat failed to acquire any appreciable tolerance, three showed incomplete tolerance at the last injection, and two showed tolerance at the third injection, reflecting individual differences in the rate of formation and decay of tolerance. It appears that the 48-hour interval may be a critical limit for the processes involved, for we encountered no tolerance in 72-hour tests with these doses.

Six rats (group C) received daily injections of mescaline, 10 mg/kg, over 10 days. Gross behavioral effects and climbing impairment following a single dose are similar to the effects and impairment following the injection of LSD-25, but with mescaline the onset is later; impairment in climbing begins at 10 rather than 5 minutes after injection, with a peak at 20 rather than 10 minutes, and a return to normal at 50 to 60 rather than at 30 to 45 minutes. Nor is tolerance development as rapid; three of the rats were completely tolerant at the fourth injection, one at the fifth, and two at the seventh. Since tolerance develops with respect to the behavioral effects of both drugs, future research must not only inquire into a possible common biochem-

Fig. 1. Median climbing time for group A rats, showing development of tolerance with intraperitoneal injection of LSD-25 (130 μg/kg). Asterisk indicates failure to climb after 60 seconds in the arena.

All technical papers are published in this section. Manuscripts should be typed double-spaced and be submitted in duplicate. In length, they should be limited to the equivalent of 1200 words; this includes the space occupied by illustrative or tabular material, references and notes, and the author(s)' name(s) and affiliation(s). Illustrative material should be limited to one table *or* one figure. All explanatory notes, including acknowledgments and authorization for publication, and literature references are to be numbered consecutively, keyed into the text proper, and placed at the end of the article under the heading "References and Notes." For fuller details see "Suggestions to Contributors" in *Science* 125, 16 (4 Jan. 1957).

ical or neural mechanism but must also explain the relative difficulty with which tolerance to mescaline is established.

To distinguish drug tolerance from "learning," the loss of impairment must be contingent upon the pattern of drug injections and not upon climbing experience. When we injected rats daily with the drug but omitted the climbing test on the second and third injection days, climbing was no longer impaired on the fourth injecion day. Conversely, when we injected rats daily with placebos and permitted them to climb daily, climbing was impaired with drug injection on the fourth day. Finally, rats in groups A, B, and C were permitted to lose tolerance; climbing was impaired with the first injection of the drug, and with daily injections the animals regained tolerance, each in its own characteristic pattern.

In a set of experiments on cardiac effects, we found that rats restrained in a holder displayed a tachycardia which was affected only slightly by single doses of LSD-25. In order to record bradycardia in rats, subcutaneous needle electrodes were attached to the limbs, allowing the animal freedom of movement during electrocardiographic recordings. Intraperitoneal placebo injections caused a tachycardia under these conditions, and injections of LSD-25 induced bradycardia, the pulse decreasing from a base of 415 to 300 per minute. Daily intraperitoneal injections of at least 175 μg of LSD-25 per kilogram were administered for as long as 12 days. Bradycardia was most marked within the first 30 minutes following injection and began to decrease at 90 minutes. Although the degree of bradycardia varied from day to day, we found no clear indications of the development of tolerance. Similarly, chronic experiments with mescaline-induced bradycardia in rats have failed to demonstrate tolerance (*5*). The bradycardia induced with LSD-25 has been thought to be due to a central mechanism, since, in the cat, LSD-25–induced bradycardia is abolished by spinal section (*6*). The peripheral anticholinesterase effects of LSD-25 would be minimal in the dosage range employed here (*2*).

Our findings and those of others suggest a pattern underlying the development of tolerance to the effects of LSD-25. No tolerance is manifest with respect to bradycardia and the respiratory arrest that occurs with high dosages (*7*); these two effects probably involve centers in the caudal brain stem. Pyrexia, mydriasis, and piloerection are autonomic effects of LSD-25 to which tolerance has been shown to develop (*6, 8*); more rostral brain-stem mechanisms have been implicated in the origin of these responses (*6*). Similarly, rostral mechanisms may be involved both in the behavioral effects and in the tolerance observed with respect to both psychosomimetic drugs. The rostral mechanisms which are involved in electroencephalographic and behavioral arousal and which show "habituation" to sensory stimulation (*9*) could as well show tolerance to chemical stimulation. This suggests that both neurochemical and electroencephalographic studies would be useful in investigating the basis of tolerance. Since tolerance may be a phenomenon characteristic of the entire group of psychosomimetic drugs, comparative studies of autonomic behavioral and electroencephalographic effects should be attempted.

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31 October 1957

Antimicrobial Activity of Horny Corals

Recent studies (*1*) on the occurrence of antibiotic substances in marine organisms have revealed some interesting antimicrobial properties of gorgonian corals, belonging to the phylum Coelenterata. Corals were collected for this work from reefs located off the southern coast of Puerto Rico. For the assays of antibacterial activity in the various materials, many indicating marine bacteria were isolated from the same region and grown in Difco nutrient agar made with sea water. Other common test microorganisms were grown in ordinary nutrient agar made with distilled water. Small pieces of coral, or various extracts from different species of coral, were placed on nutrient agar plates, which had been inoculated with the appropriate indicating microbes. After incubation for about 16 hours, zones of microbial inhibition became conspicuous around the fragments of coral and paper discs containing extracts from active corals.

Among the corals which showed antibacterial action were the following species: *Antillogorgia turgida, A. americana, Rhipidogorgia flabellum, Briareum asbestinum, Plexaura homomalla, Plexaurella dichotoma,* and *Plexauropsis crassa.* The sea whip, *Antillogorgia turgida,* was especially striking in its action against numerous marine bacteria, *Clostridium feseri, Micrococcus aureus, Bacillus subtilis,* and *Escherichia coli.* Strains of penicillin-resistant *Micrococcus* were equally susceptible to inhibition by extracts from *Antillogorgia.* Unsusceptible organisms included *Lactobacillus casei, Candida albicans, Kloeckera brevis, Cryptococcus neoformans,* and *Saccharomyces cervisiae.* It was easily demonstrated that antimicrobial activity could be extracted from both fresh and dried materials of sea whips, sea fans, and plexaurid corals, by means of water or other common solvents. The active principle appears not to be located in the brown core of the horny corals, but it is present in the outer, gray-purple cortex. This suggests that the activity is probably not associated with halogenated gorgonin of the horny axis. Segments of the fine branches, as well as the large basal stems, showed very sharp zones of inhibition on agar plates containing marine bacteria. In contrast to these results with gorgonian corals, little or no antimicrobial activity could be detected in the species of stony corals that were tested. Examples of inactive species are *Acropora palmata, Porites porites, Millepora alcicornis,* and *Montastrea sp.*

It is not known whether the coral polyps or their associated zooxanthellae produce antibacterial substances. It is of interest to note that another large group of terrestrial symbionts, the lichens, commonly produce antibiotic substances (*2*). The increasing number of examples of naturally occurring chemical antagonism among numerous kinds of organisms lends support to the idea, expressed so well by Brian (*3*), that these phenomena are "not incompatible with the view that the capacity to produce antibiotics is a character conducive to fitness." Perhaps successful symbiosis may be enhanced by the antibiotic properties of the complex organization of fungi and algae in lichens or of animals and algae in gorgonian corals.

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7 April 1958

Positive Reinforcement Produced by Stimulating Hypothalamus with Iproniazid and Other Compounds

There is a growing body of information on the distribution of possible transmitter substances in the brain and on factors which cause temporary or long-run changes in these concentrations (*1*, *2*). No technique, however, has been available to demonstrate the excitatory or inhibitory function of these chemicals in the central nervous system, nor has there been any method to demonstrate their suspected capacity to act selectively on some functional and anatomical groups without affecting others.

Pharmacotherapy in mental illness has tended to emphasize the role of epinephrine, norepinephrine, and serotonin as transmitters because these tend to be concentrated in areas of the hypothalamus and tegmentum which have proved motivational functions, and because drugs which affect mental states also affect the concentrations of these substances (*1*, *2*). These three supposed transmitters are believed to be broken down in the brain by monoamine oxidases which can be inhibited by iproniazid (*1*). Thus, the latter may have its effect by augmenting the action of one or more of these three substances.

Iproniazid, in doses of 50 mg three times daily, has recently been shown to have pronounced effects in relieving severe depressions (*3*). The therapeutic effect has been tentatively related to supposedly excitatory effects of serotonin (*3*).

In our experiments (*4*), chemicals were injected into the hypothalamus of the rat in microgram amounts to test for possible rewarding effects of chemical stimulation in areas where electric stimulation is highly rewarding (*5*). Iproniazid is shown by these experiments to be a rewarding stimulant in quantities of 1 to 2 μg. The rewarding effect is specific to the chemical and to the site of injection in the brain. Iproniazid appears to share this rewarding function with epinephrine.

In these experiments, a plastic holder was screwed to the skull of each rat. From it a pair of insulated silver electrodes and a No. 26 Huber pointed hypodermic needle penetrated into the brain. This method of implantation is our own version of a technique reported by Fisher (*6*), who had based his design on an electrode developed by one of us (J. O.) (*7*).

The strategy of the series of experiments was first to canvass a range of chemical agents on the basis of a habit established by electric reward and then, after finding agents which would sustain behavior by themselves, to train a new group of animals by means of the chemical reward alone.

In the first group of experiments, electrodes and pipettes were implanted in an area of the ventral posterior hypothalamus just in front of the mammillary body. This is the center of an extensive region in which electric stimulation is rewarding (*5*). Four animals were used in these tests.

After implantation and a 14-day recovery period, animals were trained to press a lever for electric stimulation. All animals achieved rates of self-stimulation of 2000 an hour or more; the technique used has been described elsewhere (*5*). At this point they were shifted to tests of self-injection.

In self-injection studies, a polyethelene tube was used to connect a microinjector to the rat's pipette. Each lever-pressing response caused 1/700 ml of solution to be injected into the hypothalamus. The following chemicals were tested, in solutions of 1 mg per milliliter of physiological saline: acetylcholine chloride, adenosine, triphosphate disodium salt, serotonin creatinine sulfate, epinephrine hydrochloride, norepinephrine bitartrate, and Marsilid phosphate (iproniazid). Each injection contained approximately 1.4 μg of the whole compound being tested. Also, for control, physiological saline was injected alone.

The results for acetylcholine and serotonin indicate that these do not have any rewarding effect but quickly cause the animal to lose muscular tone and apparently to go to sleep. Adenosine triphosphate and noradrenaline did not have any observable effects, in the concentrations used.

Adrenaline, on the other hand, appeared to produce approach behavior; however, in the concentrations used, it caused a loss of motor coordination, and self-injection was so slow as to leave some doubt about its rewarding effects.

In the case of iproniazid, there was striking self-injection behavior. Animals injected the chemical at rates of more than 300 self-injections an hour; this is far above the chance rate obtained with saline (see Fig. 1).

In the second set of tests, electrodes and pipettes were implanted to provide

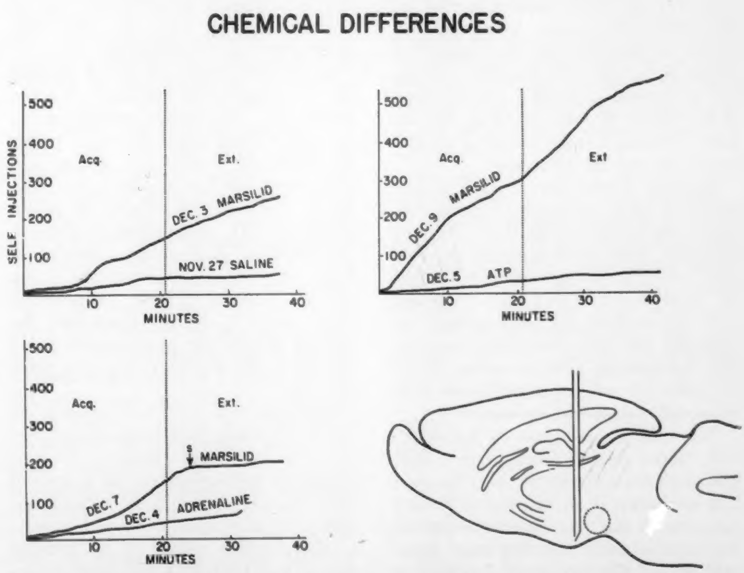

Fig. 1. Rate of response in tests with iproniazid (Marsilid) in relation to rate of response in tests with saline, adrenaline, and adenosine triphosphate (ATP). The total number of self-injections, for Marsilid, always rises to about 200 in the 20-minute acquisition period (area at left of dotted line). For saline and adenosine triphosphate, the rate does not rise above 50 (chance level). For adrenaline, the rise in rate of self-injection is slow but steady; this suggests the possibility that there are rewarding effects. Response is not rewarded by microinjections during the extinction period (area at right of dotted line). Responding tends to continue for long periods after termination of reward with Marsilid. At the point marked *S*, the animal had a seizure.

stimulation at a series of points along the floor of the hypothalamus and telencephalon. Twelve points were selected, in 12 different animals. After implantation and a 14-day recovery period, animals were trained to press a lever for chemical stimulation with iproniazid; in this case there was no prior training with electric stimulation.

Whereas all animals with ventral hypothalamic pipettes showed a better-than-chance tendency to press the bar for injection of the chemical, there was a distinct differentiation of rate of self-injection, depending on placement of the pipette. Pipettes in the posterior hypothalamus gave higher rates of self-injection than pipettes in the anterior hypothalamus. And high rates of self-injection were also obtained with pipettes in the dorsal preoptic region. These differences agree well with differences with respect to brain area in rate of self-stimulation obtained in earlier experiments with electric stimulation (*5*).

When the injector was turned off, so that bar-pressing no longer produced self-injection, animals continued to press the bar for some time (see Fig. 1), as though no change had been made. This is probably attributable to the high level of the chemical in the brain at these points and to the gradual working down of residual stores in the pipette. Extinction does eventually result from termination of the flow, after a period of about 30 to 45 minutes. Also, when the animal is shifted from an extinction period to a new self-injection period, rate of responding quickly changes from chance levels to rates of about 300 an hour. Thus, it is the chemical reward which sustains the behavior.

Injection of serotonin, by itself or immediately after injections of iproniazid, caused the animals to lie down. An animal lying down after injection of serotonin could be brought back to its feet by epinephrine. This, taken together with the tendency of some animals to press the bar for epinephrine, suggests that the exciting and rewarding effects of iproniazid are connected more with epinephrine than with serotonin.

From the experiments on self-injection, three main results have been gained. Substantively, we have learned that iproniazid is an excitant of reward functions in this motivational system of the hypothalamus, and that quite probably it has this excitatory function in common with epinephrine. Methodologically, we have validated a technique of self-injection which can now be used to resolve further the problem of the excitatory and inhibitory chemistry of the motivational systems. Finally, from the clinical point of view, we have been exceptionally fortunate in having our method select the pharmacological agent which has recently given best results in alleviating depressions, for this indicates that it is a method for locating antidepressants.

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30 December 1957

A New Phospholipid, Malignolipin, in Human Malignant Tumors

We report here the discovery of a new phospholipid—malignolipin—containing spermine, found specifically in malignant tumors, but never in normal tissues. Laborious efforts of many of our predecessors have been concentrated on the problem of finding a substance which exists only in malignant tumors and never in normal tissues, but such efforts have been unsuccessful up to the present.

In examining the affinity of various cell components for porphyrin (*1*), we noticed the very marked affinity of extracellular small bodies in cancer tissues for protoporphyrin III (*2*), and we also ascertained that the substance in normal tissues which has an affinity for protoporphyrin III, and which occurs in mitochondria and myelin sheaths, is sphingomyelin (*3*). Investigation of the chemical nature of the extracellular small bodies in cancer tissues with the marked affinity for protoporphyrin III has led to the discovery of a new phospholipid.

Sphingomyelin can be extracted by means of boiling 95-percent ethanol; the substance other than sphingomyelin with affinity for protoporphyrin III is isolated from freshly excised human malignant tumors (a seminoma, a stomach cancer, a colon cancer, a uterine cancer, a breast cancer, and Hodgkin's malignant granuloma were used in the studies reported here) by fractionation with organic solvents, as follows. A freshly excised malignant tumor is extracted with 9 volumes of boiling ethanol and filtered while hot. The filtrate is left at 0°C overnight, and the supernatant is evaporated to dryness in a vacuum, then extracted with absolute ethanol. The supernatant is added, with 2 volumes of acetone, and the solution is left at 0°C overnight. The precipitate is washed with acetone-ethanol (2:1) and then with acetone; then it is dried in a vacuum and dissolved in ether. The supernatant is added, with 2 volumes of acetone, and the solution is left at 0°C overnight. The precipitate is washed with acetone, dried in a vacuum, and dissolved in absolute ethanol. The supernatant is added, with 2 volumes of acetone, and the solution is left at 0°C overnight. Such precipitation with acetone from ether and ethanol solution is repeated till the final precipitate contains no trace of the substance that has no affinity for porphyrin (*3*). The precipitate is washed with acetone-ethanol (2:1), then with acetone; then it is dried in a vacuum and dissolved in chloroform. The supernatant is added, with 2 volumes of acetone, and the solution is left at 0°C overnight. The precipitate is washed with acetone, freed from acetone, and crystallized from chloroform. The substance with the affinity for protoporphyrin III was obtained thus, in pure state, as small hexagonal, snow-crystal-like crystals, from every one of the aforementioned malignant tumors.

This compound is very hygroscopic, is strongly basic, and is readily soluble in water, ethanol, ether, petroleum ether, and chloroform but is insoluble in acetone. In every instance, the compound obtained from the aforementioned tumors was found to contain nitrogen and phosphorus in the ratio of 5 to 1 and, quite unlike all other phospholipids that have ever been reported, to show only one spot; this spot can be revealed by Ninhydrin, as well as by Dragendorf's reagent, on the paper chromatogram developed with *n*-butanol, butanol–acetic-acid–water (4:1:5), or ethanol-water (8:1). Moreover, the compound was found not to be contaminated with other substances (the biuret test, Ehrlich's aldehyde test, Molisch's test, Bial's test, Pettenkofer's test, Feulgen's test, and the Liebermann-Burchard test were all negative).

When this lipid is left in 0.3*N* HCl at 18°C for 3 hours, the opalescent solution becomes quite transparent, with some oily droplets at the surface, the whole amount of phosphorus contained in the original lipid can be recovered as free phosphoric acid, and no trace of acetone-insoluble original lipid can be obtained from its ether extract—that is to say, the lipid is completely hydrolyzed.

The ether-soluble part of the hydrolyzate contains neither phosphorus nor nitrogen, and the following tests have all been negative: Bial's test, Molisch's test, Ninhydrin test, sodium fluorescein test, Feulgen's test, and the Liebermann-Burchard test. It has been ascertained that the ether-soluble part of the hydrol-

yzate is composed of some unsaturated fatty acid, which is solid at a temperature lower than 60°C and is obtained in rhombic crystals from ethanol solution.

The ether-insoluble part of the hydrolyzate is found to contain the whole amount of nitrogen and phosphorus involved in the original lipid and to contain no trace of Bial-positive or Molisch-positive substance. On paper chromatography of desalted hydrolyzate with butanol–acetic-acid–water (4:1:2), only one spot can be detected by means of a Dragendorf's reagent; this appears at a place quite similar to that of choline hydrochloride. Beautiful crystals of choline reineckate can also be obtained from the hydrolyzate. On paper chromatography of the desalted hydrolyzate with butanol–acetic-acid–water (4:1:5), only one nice purple spot can be detected by means of a Ninhydrin spray, at a place quite similar to that of spermine hydrochloride isolated from pigs' semen; no other Ninhydrin-detectable spot was ascertained. Choline in the hydrolyzate is, then, precipitated quantitatively as reineckate, and the optical density of an acetone solution of the reineckate at 327 mμ is measured spectrophotometrically. Spermine in the hydrolyzate is precipitated with phosphotungstic acid, the precipitate is extracted with chloroform after digestion with 50-percent K_2CO_3, and the nitrogen in the fraction extracted with chloroform is measured; this must be the nitrogen of spermine. The sum of the choline nitrogen and spermine nitrogen agrees well with the total nitrogen content of the hydrolyzate. It has also been demonstrated that phosphoric acid, choline, and spermine in the hydrolyzate are equimolar.

The existence in human malignant tumors of a phospholipid which has a marked affinity for protoporphyrin III and which is composed of choline, spermine, phosphoric acid, and fatty acid (as is shown by the following tentative formula) is thus confirmed, though the arrangement of the components and the number and kinds of fatty acid are yet to be revealed. We propose to designate this lipid "malignolipin." The tentative formula is

```
                         O
                         ‖
(CH3)3N(CH2)2—O—P—NH(CH2)3
          |               |
         OH              OH
                     N(CH2)4NH(CH2)3NH2
                     |
                     COR
```

It has been ascertained that malignolipin is never found in normal tissues, such as cattle brain or whole bodies of normal mice.

As malignolipin is found to exist richly in tumors of high malignancy and in the rapidly growing part of a tumor and scantily in necrotic tumors or in the degrading part of a tumor, this lipid is supposed to be intimately related to the malignancy of tumor cells.

The discovery of a new phospholipid, which is found only in malignant tumors and never in normal tissues, will greatly contribute not only to the diagnosis of malignant tumors but also to the elucidation of their pathogenesis and, further, to the discovery of means to make them subside.

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17 December 1957

Free Radical Formation in Reaction between Old Yellow Enzyme and Reduced Triphosphopyridine Nucleotide

In 1937 Haas (*1*) described the transitory appearance of a red color when old yellow enzyme was reduced in the presence of an excess of triphosphopyridine nucleotide (TPN). The absorption maximum of the free enzyme at 465 mμ was shifted to 475 mμ. Haas considered the red complex to be a free radical, and others have cited this as probably representing the earliest evidence for free radical intermediates in oxidation-reduction enzymes (*2*). More recently, Beinert has described spectroscopic changes accompanying oxidation-reduction of flavin mononucleotide (FMN) (*3*) and a number of flavin-containing enzymes (*4, 5*) which he attributed to free radical formation. These consisted, chiefly, in the transient appearance of a broad absorption band with maximum at 565 mμ. These spectral changes were least conspicuous in the case of old yellow enzyme. Nevertheless, Beinert was unable to confirm Haas's observation regarding the formation of a red complex. The work described in this report was undertaken to elucidate further the reaction between old yellow enzyme and reduced TPN (TPNH) in an attempt to resolve the differences between the findings of Beinert and Haas and to prove whether or not a free radical is actually formed.

Old yellow enzyme of high purity was prepared according to the method of Theorell and Akeson (*6*). Absorption spectra in clear solutions were studied with a Beckman DU spectrophotometer; microcells of 0.3 ml volume and 1 cm light path were used. Oxygen could be excluded by displacement with nitrogen and by stoppering the cuvette.

In a number of experiments under a variety of conditions, we have been able to confirm Haas's observation on the formation of an orange-red compound. An essential requirement appears to be the presence of the pyridine nucleotide in the reduced form, but addition of hydrosulfite or exclusion of oxygen is not necessary.

The red compound is best obtained by addition of a 10- to 15-fold excess of TPNH to a solution of old yellow enzyme in neutral phosphate buffer. The entire absorption spectrum is shifted about 10 mμ toward longer wavelengths as compared with that of old yellow enzyme (Fig. 1). The shift of the maximum absorption peak is obscured when a steep background absorption is present, as in the case of Beinert's experiments (*5*). At least a part of the small absorption increase between 550 and 650 mμ that he observed must have been due to this shift in absorption peak. In spite of several attempts, under varied conditions, we have been unable to observe any distinct peak in that spectral region.

By ultracentrifugation in a separation cell of the reaction mixture containing the red complex, it was established that this is a compound between old yellow enzyme and TPN. Spectrophotometric assay of the pyridine nucleotide remaining uncombined in the supernatant fraction indicated that the amount of pyridine nucleotide bound by the enzyme is equivalent to its FMN content—that is, 2 moles per mole (*6*).

Dialysis of the orange-red sedimented fractions against water does not restore the original absorption spectrum of old yellow enzyme. However, reduction with $Na_2S_2O_4$ decolorizes the solution, which after anaerobic dialysis against phosphate buffer and reoxidation in air regenerates the old yellow enzyme. This indicates that the proposed complex is very stable

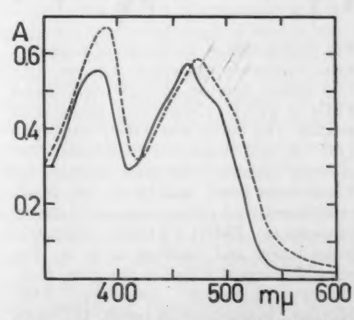

Fig. 1. Absorption spectra of old yellow enzyme (solid curve) and the red complex formed upon reaction with TPNH (broken curve).

in the oxidized form but is dissociated when reduced.

The presence of free radicals in the reaction mixture was detected by paramagnetic resonance absorption at a wavelength of 3.2 cm. The sample (20 to 40 μl of solution) was placed in a glass tube of 1 mm bore that was centered in the cavity, and measured at room temperature. The best result was obtained in the following experiment. A solution of 2 mg of TPNH in 20 μl of phosphate buffer (*p*H 7.0) was added to 5 mg of old yellow enzyme crystals which had been centrifuged from the $(NH_4)_2SO_4$ mother liquor. This resulted in dissolution of most of the crystals. The sample was transferred at once to the capillary and placed in the resonance spectrometer. The amount of free radicals increased during the first 5 hours, remained essentially constant for about 20 hours, and thereafter decreased. Between the measurements, the sample was stored at 4°C. At 33 hours the sample was temporarily removed from the capillary to obtain an aliquot of the solution for determination

Fig. 2. Records of derivative of paramagnetic resonance absorption curves: (*A*) Old yellow enzyme (1.2m*M* equivalents FMN) + TPNH (50m*M*), 5 hours after mixing. The buffer was 0.05*M* phosphate (*p*H 7.0) and 30 percent $(NH_4)_2SO_4$. The effective volume in the glass capillary (of 1 mm inner bore) was 18 μl. (*B*) Blank experiment: old yellow enzyme (0.03m*M* equivalents FMN) + TPNH (50m*M*). Same buffer and capillary as in *A*. The remaining signal is due to the glass. Conditions: microwave frequency, 9360 Mcy/sec; Magnetic field sweep, 127 gauss increasing field, 12 minutes sweep time; peak-to-peak modulation at 70 cy/sec, 27 gauss; time constant of phase-sensitive detector, 40 seconds.

of the enzyme concentration. The free radical signal disappeared following the exposure to air but returned in the succeeding hour to reach the level present upon withdrawal, then slowly decayed. The enzyme concentration was found to be 1.2m*M* (equivalents FMN). The derivative curve at maximum development of free radicals is seen in Fig. 2. A weak but still detectable signal was obtained at an enzyme concentration of 230 μ*M*.

The derivative curves recorded were compared with those obtained from FMN reduced by zinc in 1*N* HCl. They could not be distinguished from each other with respect to shape, width, or *g*-value. In fact, the curve obtained for 500 μ*M* FMN coincides exactly with that of Fig. 1.

Attempts have been made to determine the free radical concentration by measuring the magnetic susceptibility of the FMN semiquinone and by comparison with the resonance absorption of diphenylpicrylhydrazyl after extrapolation of the data to the case of an infinitely narrow cylindrical sample. Both methods indicate a maximum yield of free radicals of about 15 percent in the solution containing 1.2m*M* old yellow enzyme.

Our experiments suggest that the orange-red compound is a complex containing TPN in addition to FMN, as assumed by Haas (*1*). However, this complex is not identical with the radical structure. The low yield of free radicals and their sensitivity to exposure to air suggest that they accumulate until a steady state is reached.

Since no TPN or DPN radicals have as yet been described, it would be premature to consider the similarity between the resonance absorption spectrum of the system old yellow enzyme plus TPNH and that of the FMN semiquinone as evidence conclusively showing that the radicals belong to the FMN moiety. On the basis of the minimal extinction of 3.3×10^6 $cm^2 \times mole^{-1}$ (*7*) at 565 mμ that Beinert (*5*) has calculated for the FMN radical and our finding that the maximal radical concentration amounts to 15 percent of the enzyme concentration, an absorbance increase of about 0.045 can be calculated in case of FMN radical formation in an old yellow enzyme solution with original unit absorbance at 465 mμ. This is the same order of magnitude observed by Beinert (*5*) and emphasizes the difficulty of observing these radicals by spectrophotometric methods.

While this work (*8*) was in progress, Commoner *et al.* (*9*) presented data, obtained by paramagnetic resonance absorption technique, which indicated free radical formation in a number of other enzyme systems. However, without kinetic data, neither the finding of Commoner *et al.* nor that reported here proves that the free radicals detected represent active intermediates in the enzyme reactions.

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12 December 1957

An Undescribed Trypsin Inhibitor in Egg White

The existence of a powerful trypsin inhibitor in egg white has been noticed by some workers (*1*) since Delezenne and Pozerski (*2*) observed at the beginning of this century that fresh egg white inhibits trypsin. Meyer *et al.* (*3*) found that the active component of egg white shows the properties and composition of an ovomucoid, and recently this component was definitely identified as a native ovomucoid by Lineweaver and Murray (*4*). As a result of an investigation of the naturally occurring inhibitor in egg white against *Aspergillus* proteinase, I have reached the conclusion that egg white contains an undescribed trypsin inhibitor which is more effective than ovomucoid. This finding was derived from the observation that native egg

Table 1. Difference in properties of the trypsin inhibitors in egg white.

Test	Ovomucoid	Ovoinhibitor
Ammonium sulfate, at half saturation	No ppt.	Ppt.
Trichloroacetic acid, 2.6 %	No ppt.	Ppt.
Aspergillus proteinase	No inhibition	Inhibition
Bacterial proteinase*	No inhibition	Inhibition
Anthrone's reaction	Positive	Negative
μg of trypsin inactivated by μg of inhibitor†	0.79	0.99

* Crystalline Bioprase, prepared from culture filtrate of *Bacillus subtilis* var. *biotecus* by Nagase & Co., Ltd., Japan.
† Taken from data of Fig. 1.

white inhibits the fungal proteinase but purified ovomucoid does not.

The new inhibitor was separated from egg white as follows. Egg white was diluted with an equal volume of 0.25 percent NaCl solution and brought to *p*H 6 with HCl. The precipitate of mucin was removed by centrifugation. The supernatant was half-saturated with ammonium sulfate, and the precipitate that formed was dissolved in a small volume of distilled water. When this was dialyzed against 0.25 percent NaCl solution, more of the mucin separated (*5*). The inhibitor was then precipitated by ammonium sulfate at 0.35 saturation, dissolved in distilled water, and dialyzed in a cellophane bag against distilled water until it was free from ammonium and sulfate ions. The globulins that settled in the bag were removed by centrifugation.

To the supernatant, which was a fairly clear solution, was added trichloroacetic acid to a final concentration of $0.15M$; the *p*H was then adjusted to 3.5. After it had stood for about 10 minutes at 25°C, the precipitate was collected by centrifugation and was redissolved in distilled water. Adjustment of the solution to *p*H 4.8 (indicator paper) gave a considerable amount of precipitate of foreign protein which has no inhibitory action. After removal of the precipitate, the solution, in the presence of 1 percent NaCl, was brought to 40 percent acetone concentration at room temperature, and the precipitate that formed was discarded. The inhibitor was finally precipitated by acetone at a concentration of 60 percent. The white precipitate was washed with acetone followed by ether, and then dried in a vacuum desiccator. The yield of the inhibitor was about 0.07 g per 100 g of egg white, and the specific activity was about 63 times that of the original egg white. The proteolysis and its inhibition were measured according to the procedure of Anson (*6*); milk casein was used as substrate.

The new inhibitor, which would be called "ovoinhibitor," in contrast to ovomucoid, showed a single moving boundary distinctly different from that of ovomucoid in paper electrophoresis, and the ultraviolet absorption of an aqueous solution was typical of protein, showing absorption maximum at about 280 mμ. With the view of evaluating the potency of the new inhibitor as compared to ovomucoid, the effect of different concentrations of both inhibitors on trypsin was studied. The level of trypsin added to various levels of the inhibitors was 60 μg, and the enzyme was added to the mixture of substrate and inhibitor. Digestion was run at *p*H 7.6 for 10 minutes at 35°C. From the results presented in Fig. 1, it will be seen that the new inhibitor, like ovomucoid, inhibited trypsin

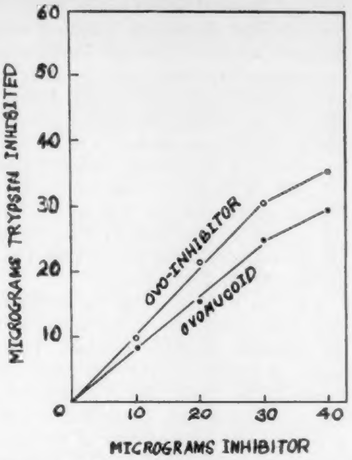

Fig. 1. Trypsin-inhibiting activity of inhibitors from egg white.

stoichiometrically and was more effective than ovomucoid. It resembles ovomucoid in that it is considerably stable in acid solution and also in that it is readily digested by pepsin but not by papain. Unlike ovomucoid, however, it gives a negative anthrone test, it was precipitated by 2.6 percent trichloroacetic acid, and it acted on proteinase of fungal and bacterial origin (Table 1).

Consequently, attention must be called to the fact that "Egg white trypsin inhibitor" does not consist only of ovomucoid; there also exists an additional inhibitor, "ovoinhibitor."

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18 February 1958

Central Synaptic Effects of ω-Guanidino Acids and Amino Acid Derivatives

The synaptic effects of the aliphatic ω-amino acids (*1*) relate to the general problem of the nature of bioelectric activity and particularly to the special properties of synaptic electrogenesis. Furthermore, at least one of the substances, γ-amino butyric acid (GABA), occurs abundantly in mammalian brain, where it is enzymatically produced (*2*). By virtue of its potent synaptic effect—selective inactivation of depolarizing (excitatory) dendritic synapses (*1*)—GABA may play a role as an "inhibitory transmitter" of a special type (*3*). While all the tested ω-homologs of GABA were synapse inactivators, their effects varied not only in degree but also in the quality of action. The latter depended upon the length of the carbon chain. The 5-carbon δ-amino valeric acid, like GABA, but less strongly, blocks selectively the depolarizing synapses of the superficial dendrites of the cat cortex (*1*). The 6- and 8-carbon compounds, on the other hand, selectively inactivate the hyperpolarizing synapses. Both are convulsant agents, ω-amino caprylic acid (C_8) being about as powerful on topical application as strychnine, which also inactivates selectively the hyperpolarizing synapses (*4*).

Thus, the affinities of two classes of synapses can now be defined in terms of electrophysiological effects and of a relatively simple configurational change in synaptic drugs. The availability, in almost innumerable modifications and in various grades, of compounds derived from amino acids offers a new series of pharmacological tools for the analysis of molecular structures of excitable membrane. One homologous series related to the aliphatic ω-amino acids is that of the guanidino acids

$$HO{-}\underset{\underset{O}{\|}}{C}{-}(CH_2)_{n-1}{-}\underset{\underset{H}{|}}{N}{-}\underset{\underset{NH}{\|}}{C}{-}NH_2$$

This series is of particular interest because γ-guanidino butyric acid ($n = 4$) normally occurs in brain (*5*), and by transamidation is a source of γ-amino butyric acid (*6*).

The method employed in the analysis of actions of the drugs on cortical synapses, detailed earlier (*1*), need be described only briefly here. Selective blockade of depolarizing dendritic synapses leads, in the cerebral cortex, to reversal of the evoked cortical response from negativity to positivity as the normally masked responses of hyperpolarizing synapses become evidenced. Because the cerebellar cortex is relatively devoid of hyperpolarizing synapses (*4*), there is no positivity to unmask by abolition of the surface negativity. Blockade of hyperpolarizing synapses in the cerebral cortex is denoted by augmentation of the surface negative response. The potential of the cerebellar cortex is not affected (*7*). These various actions are produced rapidly and reversibly, thus denoting their nature as effects of drugs upon synaptic surfaces, rather than interference with intracellular metabolic pathways. Onset occurs within 1 to 5 seconds after application of 2 to 3 drops of buffered 1 percent solution of the drug to the cortical

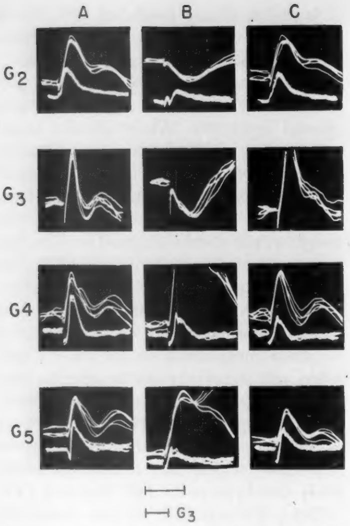


Fig. 1. Synaptic actions of ω-guanidino acids of carbon chain lengths $n=2$ to $n=5$ (G_2 to G_5). Five superimposed responses in each record before (*A*), and 20 to 30 seconds after application of three drops of the 1 percent solution of the compound (*B*), then, 10 minutes after the cortical surface is flushed with Ringer's solution (*C*). The dual trace records show simultaneous tests on the cerebral (upper) and cerebellar (lower) responses in one succinylcholine preparation. The records for G_3 (β-guanidino propionic acid) were obtained from a different preparation, and only for the cerebral cortex. The time base (20 msec in each case) is also different for these records.

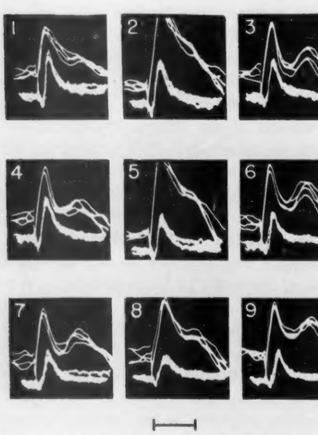
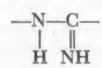


Fig. 2. Alteration of synaptic properties of ω-guanidino acids by substitutions. Modification of guanidino acetic acid (G_2) to creatine (1–3) or creatinine (4–6) produces substances that are selective blockaders of inhibitory synapses. Arginine (7–9), derived from δ-guanidino valeric acid, is a weakly acting agent. Dual traces in all records show the effects on cerebral (upper) and cerebellar (lower) dendritic activity. Four superimposed responses in each record. Time, 20 msec.

surface. Reversal begins within 10 to 20 seconds after the surface is flushed with Ringer's solution. Although intravenous injections of the amino acids produce no electrophysiological effects, local destruction of the blood-brain barrier permits the access of these substances to the synapses only in the altered cortical region (*8*). Effects similar to those produced by topical application are then seen about 15 seconds after as little as 8 mg/kg of the synaptically active amino acid is injected into the femoral vein.

Like the ω-amino acids, the ω-guanidino acids tested are synaptic agents, and all inactivate dendritic synapses. Their mode of action also depends upon the length of the chain (Fig. 1). However, the $n=2$ compound (guanidino acetic acid) is a strong inactivator of depolarizing synapses like GABA (C_4) and not like glycine (C_2). On the other hand, the $n=4$ compound, γ-guanidino butyric acid, unlike GABA, blocks not the depolarizing but the hyperpolarizing synapses, resembling in this respect the C_6 amino acid.

These differences indicate that the ω-guanidino acids of carbon lengths n behave like the ω-amino acids of carbon lengths $n+2$. Thus it would seem that the



coupling between the aliphatic chain and the terminal NH_2 of the guanidino compounds is equivalent to two carbons of an aliphatic ω-amino acid. However, the substitution is not a fully equivalent one. Whereas the ω-amino acids act rather selectively upon one or the other variety of synapses, the guanidino acids are less selective. While the butyric and valeric guanidino compounds markedly augment the evoked potential of the cerebral cortex, an indication of their blockade of the hyperpolarizing synapses, the substances also depress somewhat the cerebellar response. This indicates that the $n=4$ and $n=5$ guanidino acids also block depolarizing synapses to some extent (*9*).

The relative nonselectivity of the guanidino acids can account satisfactorily for the finding (cited in *6*) that γ-guanidino butyric acid "inhibits" the crayfish stretch receptor, but somewhat less effectively than dose GABA. A more elaborate test object, such as is available in the cortex because of the presence of both depolarizing and hyperpolarizing synapses, provides information not only upon this common aspect of the drugs, but also furnishes details about their differences.

Instructive examples of the modification of synaptic actions can be derived from compounds related to the guanidino series. The monomethyl substitution of guanidino acetic acid, without or with condensation, which yields creatine and creatinine, respectively, markedly changes the synaptic effects. The powerful inactivator of depolarizing synapses (Fig. 1) is converted into blockaders of hyperpolarizing synapses (Fig. 2). On the other hand, insertion of an $—NH_2$ group in the α-position of δ-guanidino valeric acid converts this powerful blockader of hyperpolarizing synapses into one (arginine) that acts weakly in this manner. It has been noted earlier (*1*) that the introduction of an α-amino group into the ω-amino acids diminished, or abolished, synaptic potency.

The synapic effects of the amino, or guanidino acids and related compounds, including some of the B vitamin group (*10*), and the occurrence of many of these substances in the body, indicate that synaptic as well as metabolic actions must be considered when the role of the substances in the bodily economy is described. Thus, for example, the trophic, neurological, and psychological changes that are frequently noted in the syndromes of various B vitamin deficiencies may be associated more with the synaptic effects of the substances than with their metabolic roles. In states of abnormal amino acid metabolism similar manifestations are also commonly observed. Direct synaptic actions may account for the "toxic" central nervous system effects attributed to amino acids and their derivatives (*11*, *12*).

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* Scholar, Sister Elizabeth Kenny Foundation.

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Electrode and Cannulae Implantation in the Brain by a Simple Percutaneous Method

In an investigation of the psychologically active motivational (reward and punishment) systems of the brain stimulated by electrical means, we have utilized "roving" electrodes implanted in the unanesthetized monkey's brain (*1–4*). The technique of implantation by hammering sleeve-shaped guides into the skull for these movable electrodes apparently has not been used before and simplifies the problem in chronic preparations (*2, 3, 5, 6*). The stereotaxic instrument (*7*) can be used to place the guides. During times when experiments are not being carried out on the animal, all electrodes and cannulae can be removed, leaving inconspicuous self-closing and self-healing skin lesions.

The method consists of implanting in the skull (but beneath the skin and outside the dura) a hollow tube (sleeve) which guides the electrode (or electrode array or cannula)through the skull in a definite direction into the brain. An electrode (*8*) is pushed through the skin and subcutaneous tissues, into the outer end of the sleeve in the skull, through the barrel, and thence into the brain.

The sleeves are made from stainless steel (type No. 316) hypodermic needle tubing (No. 20, 0.90 mm outside diameter, 0.57 mm inside diameter, in one case—a macaque implantation) as is shown in Fig. 1c.

In the spot desired for the implantation, a small indentation is made in the soft tissues and bone with a hardened steel spear-shaped tool (Fig. 1*a*), which is guided through a long tube-shaped rigid bearing in a director used in place of the electrode carrier in the stereotaxic instrument. The director has a cone-shaped lower end which is pressed into the skin; the spear is lightly pounded into the bone (for a distance of about ½ mm) and then is withdrawn. The sleeve is placed on the mandrel (as in Fig. 1*b*); the mandrel is inserted in the director; the mandrel and the sleeve are driven into the bone by light hammering on the outer end of the mandrel. After each one-half millimeter or so of the guide is driven into the bone, the mandrel is manually tugged lightly upwards; if it comes out of the sleeve easily, the lower end of the guide (Fig. 1*c'*) has passed the inner table of the skull (but not the dura).

After the sleeve is in place in the skull, the skin and the subcutaneous tissues are allowed to pull together over the upper end and to heal. The sleeves are placed in definite patterns in the skull by means of the stereotaxic instrument and allowed to protrude above the skull about 2 mm. The operator palpates these ends through the soft tissues and finds the opening in the sleeve with the spear's sharp tip. By pressing the cone end of the spear into the guide's outer end, the skin and subcutaneous tissues are pierced. The skin is held in place with a forceps, the spear is withdrawn, and a sharp needle is inserted far enough to puncture the dura. The needle is withdrawn, and the electrode or cannula is inserted into the sleeve and lowered into the brain. To measure the depth of penetration of electrode or cannula, a pointed scale is used to measure the distance from the outer end of the sleeve to the outer end of the inserted cylinder of the electrode or cannula. The length of the sleeve varies with the animal and the loci in the skull. For the top of the skull of a macaque of 6 kg (13.2 lb) weight, for example, suitable lengths are 3½ to 4½ mm; for the skull of a porpoise, 20 to 50 mm.

After 5 to 6 weeks, a thin plate of bone grows over the ends of guides which are flush with the skull's surface. This is easily drilled out with two beveled hypodermic needles—first with one smaller than and then with one the same size as the electrode. Five months after an implantation the bone has not grown over the outer ends of guides which protrude 1.0 to 2.0 mm above the periosteum.

From 20 to 60 zones with 1 to 2 mm resolution have been explored along each track, running from pial cortex through the brain to the base of the skull. Previously, with a stereotaxic button and roving electrodes (*4*), we explored about 500 zones in two monkeys, with no problems assignable to either intracranial bleeding or infection. Currently, two monkeys are being investigated, with sleeves in their skulls at interguide intervals of 2 mm (one with four and one with 20 sleeves, to date). Figure 2 shows an x-ray of the skull of the animal with 20 implanted sleeves (3½ to 4½ mm long) and one electrode in place.

The animal is restrained to avoid pulling out the electrodes or cannulae (*9*). Self-limited amounts of bleeding from penetration of veins does occur but does not cause detectable signs in an upright monkey nor in a floating porpoise with a closed calvarium. Using roving electrodes, we have not yet seen (in exploration of about 30 tracks, in four animals, over a period of 18 months) any

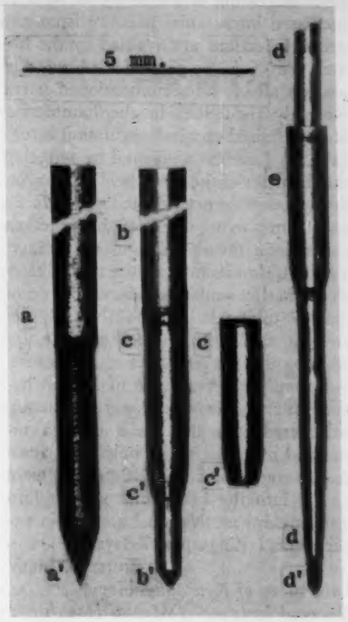

Fig. 1. Parts used in method of electrode implantation described in this report: *a,a'*, the lower end of the spear-shaped hardened steel tool (41 mm over-all length) used for starting the hole in the bone; *b,b'*, the lower part of the mandrel (41 mm over-all length), with a sleeve on the small cylindrical lower end (made of tungsten wire, 0.56 mm in diameter) (*b'*); *c,c'*, sleeves (one on mandrel and one by itself); *d,d'*, electrode; *e*, a sleeve guide on the electrode, showing a tight fit at the tapered inner end.

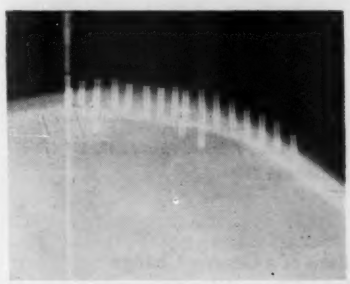

Fig. 2. X-ray photograph of monkey's skull (No. 230857, Horatio) containing 20 sleeves and one electrode; 16 sleeves are in the midplane and two are on each side, 10 mm lateral to the midplane. The latter four sleeves are displaced downward because of skull curvature, not because of deeper penetration. Careful inspection of stereo x-ray pairs shows that none of the sleeves penetrates more than a small fraction of a millimeter beneath the inside surface of the skull. Some angulation of those sleeves which were started on sloping parts of the skull can be seen; this "angulation error" has been reduced by modifications in the size of the sleeve and in the fit of the director on the sleeve (see text).

signs of tearing of an artery or signs of increased intracranial pressure from any cause. Infections are avoided by the liberal use of 70-percent alcohol on skin and on all of the aforementioned parts. Recently reductions in the hammering force required and in "angulation error" (Fig. 2) have been effected by reducing the diameter of the sleeve guide from No. 20 hypodermic needle tubing to No. 22 and by improving the fit of the director's channel on the sleeve's outside surface. The outside diameter of the roving electrodes and cannulae is reduced by use of No. 27 tubing in place of No. 24, decreasing their stiffness and, possibly, increasing the danger of arterial puncture.

Recently, sleeves made of No. 15 hypodermic needle tubing were manually hammered into the skulls of two restrained porpoises under only local anesthesia; electrodes in No. 18 needles were passed into the brain and used to find intracerebral motivational systems in experiments lasting up to 7 days.

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12 December 1957

Basis of a Genetic Change Which Invariably Occurs in Certain Maize Heterozygotes

Contrary to the well-established Mendelian principle that alternative genetic elements in heterozygotes do not merge into, or otherwise regularly transmute, each other, the entire class of $R^r rr$ seeds resulting from rr ♀ × $R^r R^{st}$ ♂ matings are weakly pigmented, whereas standard $R^r rr$ kernels within the same inbred strain are darkly mottled (*1*). The atypical phenotype recurs in orderly fashion in subsequent testcross generations, and thus is heritable. Corresponding change in the stippled character, if any, is slight, and hence is difficult to establish (*2*). Subsequent to these observations it was found that a similar, but not the same, change in pigment-producing potential occurs in R^r derived from $R^r R^{mb}$ (marbled) heterozygotes also (*3*).

Theoretically, the basis of the alteration in R^r phenotype could be either cytoplasmic or chromosomal. It is the purpose of this report to present data which exclude the cytoplasm as the site of the hereditary change in question.

One might postulate that stippled (R^{st}) maize plants carry a pollen-transmissible plasmid or cytoplasmic genetic element (*E*) which is capable of shifting the $R^r rr$ phenotype from the standard to the altered form. Thus $R^r rr$ nuclei would give darkly mottled aleurone in standard cytoplasm but weakly colored aleurone in *E* cytoplasm.

It had previously been shown that the effect of stippled on the $R^r rr$ aleurone phenotype, whatever its basis, did not appear at once after $R^{st} R^{st}$ ♀ × standard $R^r R^r$ ♂ matings (*2*). That is to say, no change in R^r expression occurs in stippled cytoplasm immediately after fertilization. The possibility remained, however, that the postulated cytoplasmic element (E) becomes effective, in terms of altering the R^r phenotype, only after R^r and E have been present together during development of the sporophyte. An adequate test of the plasmid hypothesis required that allowance be made for this contingency.

Standard $R^r R^r$ individuals were pollinated by $R^{st} r$ ♂♂. The $R^r R^{st}$ and $R^r r$ offspring were identified retroactively by the kernel phenotypes resulting from self-pollination. Each such $R^r R^{st}$ and $R^r r$ plant also was testcrossed on standard rr ♀♀. A control set of testcrosses was made by using, as the staminate parents on rr ♀♀, $R^r r$ plants from standard rr ♀ × standard $R^r R^r$ ♂ (that is, stippled was not in the ancestry). The $R^r rr$ kernels resulting from the three kinds of testcrosses may be designated as follows, giving effect to the assumed plasmid (E). (i) $A = R^r rr$ (E) from rr ♀ × $R^r R^{st}$ (E) ♂. (ii) $B = R^r rr$ (E) from rr ♀ × $R^r r$ (E) ♂. (iii) $C = R^r rr$ from rr ♀ × $R^r r$ (control) ♂.

The B and C ears were coded, and a random sample of 100 $R^r rr$ kernels from each was scored for aleurone pigmentation. The scoring was done at 13 × magnification and involved determination of the proportion of seeds in each ear sample in which pigmentation in a predetermined area exceeded that of a particular kernel of intermediate grade selected as a reference specimen.

Expectation on the plasmid hypothesis is that the control kernels (C) will show the dark mottling characteristic for standard R^r in single dose, and that both the A and B kernels will be weakly pigmented. This is based on the proposition that, if stippled plants carry a pollen-borne plasmid capable of changing the R^r phenotype from the standard to the altered form, this cytoplasmic element will be transmitted with the sperm to the eggs, and thus to the ensuing sporophyte, by the r as well as the R^{st} pollen grains formed by $R^{st} r$ plants. The significant question, therefore, is whether the B and A testcross kernels conform in phenotype.

The experimental results showed that (i) the A and B kernels did not conform to each other in phenotype but, on the contrary, were widely unlike and (ii) the B kernels did not differ significantly in aleurone pigmentation from the controls (C). Thus, there is no evidence for a plasmid (E) accompanying the r gene in the r class of pollen formed by $R^{st} r$ plants.

All the $R^r rr$ seeds on the nine A testcross ears were much more weakly colored than the reference kernel, a result in accord with earlier observations. Scoring of the 100-kernel samples from the 10 ears in the B group gave the following percentages of seeds darker than the specimen kernel: 76, 29, 74, 48, 65, 38, 58, 57, 46, and 50. The average is 54.1. The corresponding values for the ten control ears (C) were: 43, 48, 76, 31, 31, 43, 30, 47, 59, and 42. The average in this case is 45.0. Thus, the B kernels were somewhat more darkly pigmented, on the average, than the controls. The difference between the means, 9.1 ± 10.21 kernels, however, lies well within sampling limits.

The data, therefore, negate the hypothesis that the change in R^r pigment-producing potential arising in $R^r R^{st}$ plants is attributable to a plasmid. The breeding facts, on the other hand, lend positive support to the conclusion not only that the phenomenon is chromosomal but also that it is the R^r region which is involved. Assortment of the capacity to promote heritable change in R^r action with R^{st}, but not r, gametes formed by $R^{st} r$ plants shows that the stippled allele, or a neighboring factor, induces the transallelic effect. Similarly, the regularity with which the change induced in the homologous chromosome subsequently follows R^r in inheritance demonstrates that it is the R^r allele, or a closely associated element, which is genetically altered in $R^r R^{st}$ heterozygotes (*4*).

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1. The gene symbols used are as follows: R^r = self-colored aleurone, except in $R^r rr$ endosperms, which are darkly mottled; R^{st} = stippled aleurone; R^{mb} = marbled aleurone; r = colorless aleurone.
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3. R. A. Brink and W. H. Weyers, *Proc. Natl. Acad. Sci. U.S.* 43, 1053 (1957).
4. This report is paper No. 681 from the Department of Genetics, College of Agriculture, Uni-

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9 December 1957

Measurements of External Environmental Radiation in the United States

Recent interest in the dose to man from natural radioactivity has been stimulated by the assumption by many geneticists of a linear relationship between radiation dose and the incidence of genetic mutations. Although this has not been demonstrated at the low dose rates prevailing in nature, the likelihood of such a relationship has led to the suggestion that geographical variations in the frequency of spontaneous mutations may be correlated ultimately with differences in the radiation dose to populations (*1*). This question has recently been reviewed by Gopal-Ayengar (*2*).

The studies of the dose received by man from naturally occurring ionizing radiations can be divided into that received from external and internal sources. The dose to the germ plasm is primarily due to the external radiation, although one internal source, potassium-40, does deliver a dose to the reproductive organs amounting to about 15 mr/year (*3, 4*).

Studies of the radiation dose from external natural sources have been reviewed by Sievert (*3*), Libby (*4*), and Lowder (*5*), and extensive sets of measurements with particular emphasis on dwellings have been reported by Hultqvist (*6*) in Sweden. Although measurements have been made in this country by Hess (*7*) and Neher (*8*), no systematic study of the environmental radiation dose rate over an extensive area of the United States has been reported previously.

During the summer of 1957 our laboratory made measurements in the United States to establish the approximate range of population exposures to cosmic and terrestrial gamma radiation. An effort was made to obtain results which would be representative of the unperturbed natural background, affected as little as possible by the occasional substantial variations in the observed natural radiation levels produced by localized sources (for example, the proximity of granite buildings, brick paving, and fallout).

Measurements were made with a 20-lit., air-filled, polyethylene-walled ionization chamber at atmospheric pressure inside an automobile under essentially identical field conditions of loading and ionization chamber orientation. It had been established previously that the attenuation by the vehicle did not affect the measured values in an important way (about 5 percent). The ionization current was measured with a vibrating-reed electrometer, connected as a continuously reading voltmeter and driving a pen recorder. To shield it completely against beta radiation, the chamber was mounted in an aluminum container so that, including the polyethylene wall, the gas volume was enclosed by 1.08 g/cm^2 of material, corresponding to the Feather range of a 2.26-Mev beta particle.

As is well known, minute alpha contamination in an ion chamber at atmospheric pressure can produce an ion current which may be of the same order as the ion current being measured. For this reason it is important that the effect of the contamination be measured or that the alpha-produced current be suppressed. Several different methods have been used by previous investigators. In our measurements we have resorted to a technique which relies on the difference in electric fields necessary to effect total collection of ion pairs produced by particles of low and high specific ionization —that is, electrons from gamma or cosmic-ray interactions and alpha particles, respectively (*9*).

Readings were taken at 155 locations in 19 states, between New York and Utah. The natural environmental radiation levels encountered ranged from a low of 8.4 μr/hr along the Pennsylvania Turnpike to a high of 38.6 μr/hr at the summit of Pikes Peak (altitude 14,110 ft). A summary of the dose rates measured in the principal cities along the route is given in Table 1. Of the major cities listed, Denver had the highest natural background, an average of 18.5 ± 1.5 μr/hr; this level is almost twice that found in eastern and midwestern cities.

These measurements were made during part of the period of Operation Plumbbob, the 1957 series of United States continental weapon tests at the National Test Station in Nevada, and these tests influenced certain of the measured values. Elevated levels were encountered in eastern Arkansas (26.0 to 50.2 μr/hr) and in the Black Hills of South Dakota (22.0 to 33.8 μr/hr). That the initial elevated levels were attributable to fresh fallout was demonstrated by the reduction in the measured levels

Table 1. Environmental radiation levels measured in principal United States cities during August 1957. The number of observations for each range is shown in parentheses. Elevated radiation levels produced by localized sources are shown in the last column.

Location	Range of radiation levels (μr/hr)	Mean annual dose (mrad)*	Av. pressure (in.-Hg)	Atypical radiation levels (μr/hr)
Harrisburg, Pa.	9.6–11.9 (2)	88	29.8	
Pittsburgh, Pa.	9.8–13.9 (3)	96	29.2	
Cleveland, Ohio	10.5–11.8 (2)	91	29.4	
Toledo, Ohio	8.7–10.0 (2)	76	29.5	14.9 (over granite paving stone)
Chicago, Ill.	10.3–11.6 (4)	88	29.4	17.0 (adjacent to U.S. Post Office, of granite construction)
Madison, Wis.	10.1–10.4 (3)	84	29.1	
Minneapolis–St. Paul, Minn.	9.1–12.5 (4)	92	29.3	
Sioux Falls, S.D.	11.5–11.8 (2)	95	28.8	
Cheyenne, Wyo.	17.2–17.6 (2)	142	24.4	
Denver, Colo.	16.6–19.4 (10)	147	25.0	22.4 (between U.S. Mint and City and County buildings)
Colorado Springs, Colo.	19.3–22.3 (4)	168	24.2	
Grand Junction, Colo.	15.7–18.4 (3)	138	25.5	
Albuquerque, N.M.	13.8–14.5 (4)	116	25.2	
Amarillo, Tex.	12.9–13.6 (4)	108	26.4	
Oklahoma City, Okla.	9.9–10.5 (4)	84	28.7	
Tulsa, Okla.	10.8–11.6 (4)	92	29.3	
Little Rock, Ark.	12.8–13.3 (2)	106	29.7	
Memphis, Tenn.	9.4–11.0 (2)	83	29.8	13.3 (near brick apartment house)
Chattanooga, Tenn.	11.1–12.3 (2)	95	29.6	14.8 (near brick-faced motel units) 16.1 (on narrow business street; 8th between Broad and Market)

* Dose in soft tissue, assuming constant dose rate. 1 rad = 100 erg/g; 1 μr/hr = 8.152 mrad/yr.

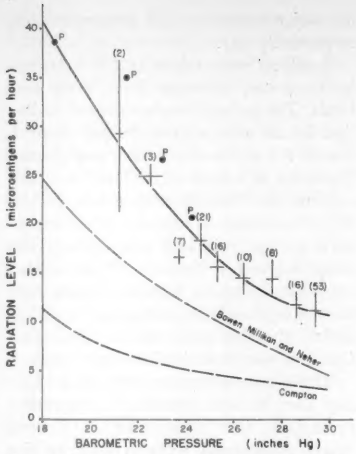

Fig. 1. Variation of environmental radiation dose rates with barometric pressure. The lower curves are for cosmic radiation intensities alone. The number of observations incorporated in plotting each point is shown in parentheses. Points marked *P* are observations on Pikes Peak.

by 50 to 75 percent upon resurvey about 3 weeks later. A resurvey of the Denver area almost 3 months later furnished results essentially identical with those of the earlier survey.

In general, one finds that the background radiation level increases as a function of decreasing barometric pressure. This is shown in Fig. 1, for which the data have been reduced in the following way. When the radiation levels were demonstrably elevated from local sources, the measurements were removed from consideration. The remaining 137 measurements were classified according to the barometric pressure at the time of measurement in intervals of 1 in. of mercury. The average values and standard deviations of the measured background and pressure for each pressure interval were then calculated; these results are exhibited in the figure. The number of observations for each pressure interval is indicated in parentheses. The four Pikes Peak observations are plotted separately as *P*, though they have also been included in the averages. The point with barometric pressure 21.2 in. of mercury has a large standard deviation in the measured radiation level, being derived from only two observations which differed substantially (Pikes Peak Highway, 35.0 μr/hr, and Leadville, Colorado, 23.5 μr/hr).

On the same figure are plotted the adapted ionization chamber measurements of the intensity of the cosmic radiation alone by Bowen, Millikan, and Neher (*10*) and Compton (*11*). The most important difference between these two sets of cosmic-ray data is the amount of filtration of the ion chambers used; in the first set, measurements were made in a thin-walled chamber (0.5 mm of steel), while Compton's measurements were made with the argon gas cavity shielded with 5 cm of lead and 2.5 cm of bronze in addition to the steel wall of the chamber.

It should be pointed out that even at sea level the numerical value of the total cosmic-ray intensity is not something on which there is universal agreement. Burch, in his critical review (*12*), concluded that the best value for the ionization intensity at sea level may be deduced from the experimental work of Clay. This value is 1.77 ion pairs/cm^3 sec (3.1 μr/hr) compared with Neher's value (*13*) of 2.74 ion pairs/cm^3 sec (4.8 μr/hr). Hess's value (*7*) of 1.96 ion pairs/cm^3 sec (3.4 μr/hr) falls between these two. It would appear that the discrepancies are too large to depend merely on differences in the thickness of the ionization chamber wall or on calibration technique.

If the results of our measurements are compared with the cosmic-ray data of Bowen, Millikan, and Neher, it is clear that a substantial part of the variability in mean outdoor radiation intensities over extensive areas in the United States is attributable to the variation in the intensity of cosmic radiation with altitude. Most of the measurements made at higher altitudes were obtained in Colorado, and the shift of the total radiation curve in Fig. 1 away from the cosmic-ray curve at higher altitudes may be due to a higher terrestrial radiation component in the mountainous areas of Colorado.

Expressed on an annual basis, our measurements indicate a range of approximately 70 to 175 mrad/yr for external environmental radiation dose rates in populated areas in the United States, with the lower dose rates prevailing in the more populated eastern and mid-western states. This compares with estimates made in the recent report of the National Academy of Sciences on the biological effects of atomic radiation (*14*), which gives an average annual background dose of about 135 mrad and a maximum dose of about 170 mrad in populated areas.

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20 February 1958

A Differentiation of Spontaneous Unit Firing in Subcortical Structures of the Cat's Brain

On many occasions, reports have attempted to establish a relation between the patterns of spontaneous discharges of neuronal units in the brain and the mass voltage fluctuations as recorded, for instance, in the electroencephalogram. Interesting observations have already been made which permit a differentiation in this respect among various types of neuronal behavior. For simplification, it may be possible to restrict the distinction to the existence of only two general categories. In subjects either without anesthesia or under light barbiturate anesthesia, one may observe (i) the production of bursts of high-frequency cellular spikes occurring in a more or less fixed phase relation to the local slow rhythmical activity or (ii) a relatively regular and continuous firing completely unaffected by the potential variations of the base line.

Typical samples of these two patterns are illustrated in Fig. 1*A*, which shows the simultaneous microelectrode recordings from two subcortical neurons of a cat under light Nembutal anesthesia. Such patterns are largely represented in various cortical and subcortical structures and, although a further differentiation could be achieved inside these groups by a finer analysis, the two extreme cases described here would conveniently define the more commonly encountered alternatives under the specified experimental conditions of recording.

On the assumption that these differences in spontaneous firing may assist in the recognition of functionally differing neurons or neuronal organization, or both, records of neuronal activity were systematically derived with microelectrodes from various diencephalic and mesencephalic regions of the cat's brain. The animals were prepared under ether anesthesia and paralyzed with Flaxedil. The slow wave activity captured by the microelectrodes was observed as it naturally

occurred after some time of rest in the absence of external perturbing stimuli; or, more often, spindle bursts were induced by the intravenous injection of small doses of Nembutal (6 to 12 mg at one time, repeated if necessary). Histological control studies were made at the completion of the experiments.

The first results to be presented here concern the unit behavior under Nembutal anesthesia. The study of 96 spontaneously firing neurons gave the distribution shown in Table 1.

From Table 1 it may be seen that distinction appears in relation to the sites of recording—that is, a typical grouping of discharges in bursts related to the slow-wave activity was generally observed in all thalamic nuclei (whatever functional significance the latter have), the only exception being that of the posterior part of the center median and nucleus parafascicularis. But, on the other hand, it was quite impossible to find any such grouping of discharges in the region of the mesencephalic reticular formation. It seems worth while to note that, so far, this distinction was achieved with a 100 percent correlation in 96 cases.

Furthermore, although less extensive, the experiments performed on unanesthetized cats yielded similar conclusions. When sufficient waiting time was provided, the fast-wave activity shown on the electroencephalogram spontaneously slowed in the absence of external stimulation. Correspondingly, the continuous firing of active thalamic neurons would first decrease in frequency and then group itself in bursts of discharges at the rate of the slow rhythmic fluctuations of the base line. Samples taken in the course of such a transformation pattern are shown in Fig. 1*D*. In no instance would these sequences be observed at the level of the mesencephalic reticular formation, where the slow rhythmic waves do not alter the sustained cellular firing (Fig. 1*C*).

Table 1. Distribution of different patterns of spontaneous unit firing under Nembutal anesthesia in relation to the sites of recording (*5*).

Sites of recording	No. of recorded units: Discharging in bursts (as in Fig. 1*A* upper trace)	No. of recorded units: Discharging continuously (as in Fig. 1*A* lower trace, and Fig. 1*B*)
Thalamic sensory relay nuclei: (VPL, VPM, GM)	13	
Diffuse thalamic projection system: (VA, VM, CL, Pc, NCM)	19	
(cM and Pf in frontal planes 6, 5, and 7)		6
Other thalamic nuclei: (LP, MD, LD, AM)	15	
Substantia reticularis mesencephalica		38
Zona incerta		3
Region of the posterior commissure		2

It seems interesting to note that other observations made by different authors in study of the spontaneous activity in various subcortical structures (*1*) may readily be entered under the classification proposed here for an anatomical distribution of "burst" and "no-burst" activity. What would be the reasons for this anatomical distribution? The subdivision made here groups together the sensory relay and the thalamic diffusely projecting nuclei in opposition to the more caudal portion of the reticular system. Strikingly, this recognition of two parts in the reticular system, with their transitional zone at the level of the center median, corresponds perfectly to classical differentiations based on anatomical and physiological evidence. Anatomically, the center median is considered the intermediary link between the thalamic and mesencephalic reticular structures, with especially large and widespread connections with all remaining nonspecific cell groups (*2*). Physiologically, the center median is also the posterior limit of regions yielding cortical recruiting responses. Its posterior pole (at Horsley-Clarke frontal planes 6 and 7) does not seem to belong to the thalamic recruiting system (*3*), but it probably represents the rostral extent of the regions from which a generalized cortical desynchronization may be elicited by high-frequency stimulation.

It does not seem that the absence of the described burst pattern in certain loci is wholly justified by the lower intensity of local slow rhythmic potentials at those points, as far as this variable may be quantitatively estimated in microelectrode recordings. It is rather suggested that these findings stress one aspect of the functionally differing organization in subcortical cell groups. Indeed, many arguments favor the representation of specific and nonspecific thalamic systems as large channels of parallel lines projecting to more or less defined areas, whereas the mesencephalic reticular system is conceived as a much more intricate network of interconnecting elements. Hence, the burst type of unit activity would appear as a character of parallel circuits where some type of synchronization—very different from the strychnine hypersynchronicity (*4*), for instance—may easily occur. Further studies are under way in order to make this hypothesis more precise.

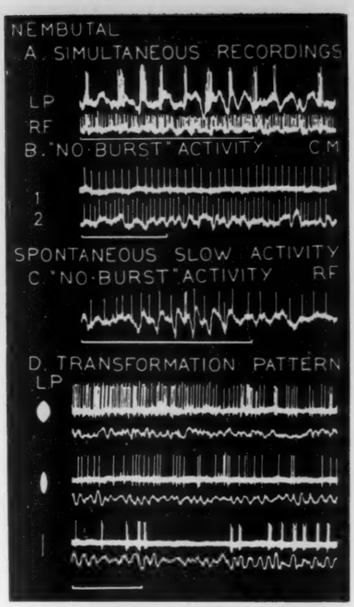

Fig. 1. Spontaneous unit activity in cat's subcortical structures. (Spontaneous patterns in an unanesthetized cat; time marks: 1 sec.) (A) Simultaneous recordings from nucleus lateralis posterior (**L.P.**) and mesencephalic reticular formation (R.F.) under light Nembutal anesthesia. (B) Successive recordings from the center median (C.M.) before (1) and after (2) injection of Nembutal. (C) Mesencephalic unit firing uninfluenced by the spontaneously occurring slow wave activity. No anesthesia. (D) Unit in nucleus lateralis posterior (L.P.); successive sequences showing the decrease in firing frequency which usually precedes the production of bursts. In each row, the lower trace is the simultaneous low band-pass recording from the same microelectrode. At left, drawings of the corresponding pupillary dilatation.

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6 December 1957

Letters

Current Scientific Journals

May I briefly discuss one statement made in your timely and excellent editorial entitled " Strength through union" and published in the 14 February issue of *Science* [**127**, 313 (1958)].

At the end of the second paragraph you speak of "50,000 scientific journals" which "currently publish about 2 million articles per year." On several occasions I have seen a like estimate of the number of current scientific journals and of published scientific articles, and I have never understood the estimates. For a discussion of this subject please read the editorial entitled "Lost-literature legend" which appeared in *Chemical and Engineering News* [**30**, 505 (1952)].

It seems to me that some definitions and some qualifying comments would be appropriate in this connection. What is a *scientific* journal?

From time to time chemistry is used in the experimental work of most branches of natural science. Accordingly, *Chemical Abstracts* must examine many scientific journals in order completely to report the new information of chemical interest appearing throughout the world. We have been striving for complete coverage for over fifty years now and feel that we have been succeeding reasonably well. We only find articles suitable for abstracting in about 7500 current periodicals.

We realize, of course, that there are a good many scientific journals which do not carry even a single article of at least a little chemical interest now and then, but I would be surprised if there can be proved to exist more than 15,000 or 20,000 journals worthy of being rated as current *scientific* journals. At least, I believe this to be true for publications which deserve to be considered in connection with scientific research. Perhaps the high estimate which I believe to be wrong includes the many small local publications such as county health bulletins, city medical association circulars, house organs, lesser trade journals, hospital bulletins, and publications for agriculture, home economics, and clinical medicine as examples of fields in which much is published. Some publications of these kinds do contain new information of a scientific nature, but a great many of them are of no real value in connection with scientific research. Such publications have various kinds of values (I do not belittle them), but they are hardly scientific journals for the most part, and abstracting journals published to aid in scientific research can usually pass these publications by with impunity.

At least it is misleading to speak of 50,000 current scientific journals if the inference is made that the information in all should be made available to scien-

tific research workers by the abstracting and indexing services. The research worker would be hindered instead of served thereby.

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Communicative Accuracy

Science has touched on a timely and urgent point in Warren Weaver's editorial on "Communicative accuracy" [**127**, 499 (1958)]. I suggest that it be an opening to a more extensive and thorough study. Pushed on its way by the AAAS, such a study can be of great service to the country.

Serious and difficult as the problem posed by Weaver is, it is multiplied in complexity for both the public at large and the Government by the simple fact that too often the scientists who are describing their activities are interested in more than "communicative accuracy" as such. They have axes to grind. Many of their topics involve problems sufficiently technical so that, even if the scientists spoke as precisely as they would like, and used caveats, it still would be difficult to come to a common understanding leading to a practical solution—that is, one that could lead to a policy, for instance. If scientific problems—particularly those involving a dispute, real or apparent—are aired in public without precision of statement and use of qualification, it may turn out that sides are picked and each side talks at the other, and a real solution becomes ever farther away.

I would suggest that part of the reason that scientists, in talking to the public or to the Government, find their communications problems difficult is that they have not thought either deeply or comprehensively enough about the public policies which their scientific statements are supposed to relate to. They have not thought enough about the framework in which policy will be made or about the constraints and conceptual models that might apply. The result is that scientists, even those most sincere and wishing to be and appear unbiased, will overstate points and then find themselves trapped by a misinterpretation of something that didn't need to be said in the first place. Often enough, too, it is the scientist speaking in too narrow a framework, lacking the vision to speak in a properly informative way.

In defense of the scientist it should be pointed out that neither the Government nor the press—even the "blue-ribbon" press—is inclined, even if able, to be always unbiased in seeking the facts. They too grind axes. In interviews, hearings, and even in conversations, questions are fed that invite the biased answer, particularly—as is often true and not

always by coincidence—if the biases of the questioner agree with those of the scientist.

But the careful scientist needn't fall for this. How many scientists, on the spot before Congress or on television, will come out and say they are not competent to speak on a point, or will draw a line between their own expert and their own lay opinion? Sometimes yes, but rarely enough to make the questioner suspect a desire not to answer the question rather than a desire to be simon-pure. The ego of the scientist is here apparent, and he will repeatedly speak with equal conviction on points on which he is expert and on points on which he is not even reasonably well informed.

It seems to me that it is not to be expected that a simple answer to these communications problems will be forthcoming. Maybe, in fact, both the Government and the press will have to face up to the fact that scientists are people. I guess the best known method on earth for getting at real "communicative accuracy," as Weaver speaks of it, is by taking advantage of the always existing interplay and conflict of personalities—that is to say, biases. Lawyers cross-examine. In the [Congressional] hearings last year on "The nature of radioactive fallout and its effects on man," the discussion seminar, with panels of scientists of not too coincident views, was used to advantage. What was brought out by these seminars perhaps was of no importance to science, but it was important from the standpoint of what scientists had to say about fallout. Scientists, facing each other across the table, literally or figuratively, are going to be more careful about "communicative accuracy." Reputations are at stake.

Similarly, the Government and the press are going to have to go much farther toward obtaining sufficient basic technical competence to avoid being "snowed" by overzealous, or just plain erroneous, scientific statement. I myself do not feel that obtaining this competence is impossible or even necessarily very difficult, once the need is recognized. Clear thinking and understanding of basic scientific facts, principles, and philosophy will go a long way toward giving this competence.

Not to go in this direction means continued reliance, without understanding, on the statements and judgments of scientists. For both the press and the Government, such reliance is often placed on a very few individuals of high reputation. (Government secrecy in excess has, as one of its more insidious effects, the furthering of this tendency to lean in one direction; either the facts can't be brought out publicly or else only one "side" knows them.) It seems to me that for either press or Government to lean heavily on one, or a few, scientists can be exceedingly dangerous.

HAL HOLLISTER

Bethesda, Maryland

Fluorescence of Ethylenediamine Derivatives of Epinephrine and Norepinephrine

A. de T. Valk, Jr., and H. L. Price [*J. Clin. Invest.* **35**, 837 (1956)] and more recently G. F. Mangan, Jr., and J. W. Mason [*Science* **126**, 562 (1957)] reported the observation that a greater fluorescence is obtained when the condensation of ethylenediamine with epinephrine [H. Weil-Malherbe and A. D. Bone, *Biochem. J.*, **51**, 311 (1952)] is performed in a solution containing acetic acid which had been passed over a column of alumina than when it is performed in water, or in acetic acid not thus treated. According to Valk and Price this difference amounts to 100 to 150 percent; Mangan and Mason found a difference of only 30 percent.

This phenomenon, of course, would not have escaped our notice if it had occurred under our conditions. Checks on the adsorbant have been and still are regularly carried out in our laboratory; the recoveries of epinephrine, after adsorption on a column of alumina, vary between 80 and 100 percent, but they never exceed 100 percent. We repeatedly and unsuccessfully attempted to observe the effect by adding epinephrine to dilute acetic acid which had been filtered through a column of alumina. We also added aluminium ions to epinephrine solutions; these did not affect the fluorescence of the ethylenediamine-condensation product up to concentrations of $10^{-4}M$. At higher concentrations they reduced the intensity of fluorescence.

Both Valk and Price and Mangan and Mason used the Farrand fluorimeter, which differs from our fluorimeter in that test tubes are used instead of rectangular cuvettes and the fluorescent solution is exposed to focused exciting light instead of parallel exciting light. We therefore measured the fluorescence of the condensation product, prepared in the presence and absence of alumina-treated acetic acid, under conditions approaching those obtaining in the Farrand fluorimeter. Again, no difference was found.

Neither Valk and Price nor Mangan and Mason made any attempt to offer a rational explanation for their observation. In view of our failure to confirm it, the burden of finding its cause rests with them.

H. WEIL-MALHERBE
A. D. BONE

Runwell Hospital, Wickford, Essex, England

Meetings

International Genetics Congress

The tenth International Congress of Genetics will be held at McGill University in Montreal 20–27 August. This is the second International Congress of Genetics to be held in North America (the first took place in Ithaca, N.Y., in 1932), and the first in Canada. An invitation to hold this congress at McGill was extended at the last congress (in Bellagio, Italy) by McGill and sponsored by the Genetics Society of America.

The invitation was unanimously supported by the Permanent International Committee for Genetics Congresses and approved at a plenary session of the congress. Since then the following organizations have enlisted as cosponsors: Genetics Society of Canada, Agricultural Institute of Canada, American Cancer Society, American Eugenics Society, American Genetic Association, American Society of Agronomy, American Society for Animal Production, American Society for Horticultural Science, American Society of Human Genetics, American Society of Naturalists, Society for the Study of Evolution.

Sewall Wright of the University of Wisconsin is president of the congress, and the vice presidents are: L. S. Penrose, University College, London, England; C. Pavan, University of São Paulo, São Paulo, Brazil; Y. Sinoto, International Christian University, Tokyo, Japan; A. Müntzing, Mendelska Sällskapet Genetiska Institutionen, Lund, Sweden; A. Sturtevant, California Institute of Technology, Pasadena, Calif.; and W. P. Thompson, University of Saskatchewan, Saskatoon, Saskatchewan. J. W. Boyes, Department of Genetics, McGill University, Montreal, P.Q., is the general secretary.

The scientific program will consist of symposia, invited papers, contributed papers and demonstrations, exhibits, panel discussions, and special meetings. A very extensive exhibit, illustrating the numerous ways in which the science of genetics has contributed to human progress and welfare, is being prepared. There will be about 100 booths, including many exhibits brought from Japan especially for the congress, a number being prepared by the Department of Agriculture of the Government of Canada, some by the U.S. Department of Agriculture, and some by the Swedish Seed Association.

The Japanese exhibits will illustrate genetic and cytological work on morning glory, wheat, rice, radish, silkworm, goldfish, and fowl. Exhibits on plant genetics will include examples from studies of coffee, cotton, sorghum, watermelons, rubber, and hybrid corn; crop improvement through crosses with wild relatives will also be shown.

Studies on animal genetics will be illustrated by exhibits of the King Ranch Santa Gertrudis cattle; dwarf cattle, fur animals, sheep and poultry; and possibly of dogs, cats, and swine. There will be a section concerning the use of genetics in relation to medicine, with displays on the use of inbred strains of animals, living chromosome maps of the mouse, immunogenetics of tissue transplants, human cancer genetics, cancer in animals, twin studies, and radiation biology.

The Canadian exhibit will demonstrate aspects of the application of genetic principles to studies of wheat, oats, Lacombe hog, poultry, legume breeding, flower color, and tomatoes.

There will be three public lectures for the general public. The Huskins Memorial Lecture of the Genetics Society of Canada will be presented in English by Arne Müntzing, chairman of the Mendelska Sällskapet Genetiska Institutionen of Lund, Sweden, in the Sir Arthur Currie Memorial Gymnasium at 8 P.M. on 19 August; a public lecture in French will be presented by Dr. Jacob in the auditorium of the University of Montreal at 8 P.M. on 21 August; and a lecture in English will be given by Theodosius Dobzhansky of Columbia University at the Sir Arthur Currie Memorial Gymnasium at 8 P.M. on 25 August.

Invitations have been extended to some 60 countries through the Department of External Affairs in Ottawa. The general secretary has extended personal invitations to more than 230 individuals and about 300 institutions in many different countries. The responses to these invitations have been numerous and encouraging. The United States Finance Committee has raised more than $50,000 to be used in helping overseas geneticists to come to the congress. Official delegates of 17 universities (or other organizations) have already been appointed and many more are expected. Countries which will be represented by these delegates include Italy, England, Switzerland, Japan, Netherlands, Poland, Greece, West Germany, the Union of South Africa, and Australia. For further information write to Prof. J. W. Boyes, General Secretary, X International Congress of Genetics, McGill University, Montreal 2, P.Q., Canada.

Pacific Division of the AAAS

The 39th annual meeting of the Pacific Division of the AAAS will be held on the campus of Utah State University, Logan, 16–20 June. Registration will open at 1 P.M. on 15 June and at 8 A.M. on subsequent days.

The divisional symposium, on the subject "Cenozoic History of the Western

United States—Geomorphic, Climatic, Ecological," will be held on the evening of 16 June. On 18 June the Council of the Pacific Division will meet at 4 P.M. The presidential address of Ian Campbell, president of the Pacific Division, will be given that evening.

Nineteen societies affiliated with the Pacific Division will participate in the Logan meeting, with symposia and sessions for the reading of papers. Local arrangements are in charge of a general committee, which is under the chairmanship of J. Stewart Williams, dean of the Graduate School of Utah State University.

International Dairy Congress

United States scientific and technical workers in the field of dairy science have been invited to participate in the 15th International Dairy Congress, to be held in London, England, 29 June through 3 July 1959. The congress is under the direction of the International Dairy Federation. Arrangements for United States participation are being handled by R. E. Hodgson of the U.S. Department of Agriculture. A committee of USDA specialists is being named to assist him.

Those who wish to propose papers for inclusion in the program and proceedings of the congress are requested to advise Hodgson *not later than 25 May 1958*. Correspondence indicating title and subject matter should be addressed to Dr. R. E. Hodgson, Animal Husbandry Research Division, U.S. Department of Agriculture, Beltsville, Md. Papers are limited to 2000 words. All manuscripts are to be submitted *by 15 August 1958*.

The United Kingdom Dairy Association, with the approval of the British Government, is organizing the 1959 congress. Organizing secretary is A. W. Marsden, XV International Dairy Congress, 86 Brook St., London, W.1, England.

Seventh National Clay Conference

The seventh National Clay Conference will be held 20–23 October at the U.S. National Museum, Washington, D.C. Sessions will be open to all who have a common interest in clays and clay technology. The meeting is sponsored by the Clay Minerals Committee of the National Research Council and is under the chairmanship of Dr. H. F. McMurdie of the National Bureau of Standards.

A principal theme for the conference will be "Geology of Clay Deposits." However, papers will also be presented on other phases of the broad subject of "Clays and Clay Minerals." Complete details of the program will be announced

in August. Abstracts of proposed papers should be sent *by 1 June* to the program chairman, John G. Cady, Soil Survey Laboratory, Plant Industry Station, U.S. Department of Agriculture, Beltsville, Md.

Development and Growth

The Society for the Study of Development and Growth will hold the 17th Growth Symposium, 9–11 June, at Mount Holyoke College, South Hadley, Mass. The theme of the symposium, which is supported in large part by a grant from the National Science Foundation, is "Differentiation and Growth in Response to a Changing Chemical Environment." The principal speakers are: C. E. Wilde, Jr.; A. Nason and F. Vasington; H. Hoffmann-Berling, Heidelberg, Germany; A. Csapo; C. Lutwak-Mann, Cambridge, England; L. C. Luckwill, Bristol, England; F. W. Loomis; F. Moog; J. G. Torrey; and H. Schneiderman. Leading the discussions will be: H. E. Lehman, N. O. Kaplan, F. Carlson, Andrew G. Szent-Györgyi, D. W. Bishop, J. P. Nitsch, J. P. Trinkaus, S. C. Shen, R. O. Erickson, and D. Bodenstein.

Housing and meals will be provided in the college dormitories; total cost per person, including room, meals, and the banquet and smoker, will not exceed $30. Anyone interested in the program may attend whether he is a society member or not. Nonmembers who wish to reserve dormitory accommodations should write immediately to Dr. Kathryn Stein, Department of Zoology, Mount Holyoke College.

Forthcoming Events

June

16–18. American Neurological Assoc., 83rd annual, Atlantic City, N.J. (C. Rupp, 133 S. 36 St., Philadelphia 4, Pa.)

16–18. Military Electronics Conv., 2nd, Washington, D.C. (G. Rappaport, Emerson Radio & Phonograph Corp., 1140 East-West Highway, Silver Spring, Md.)

16–18. Photochemical Apparatus Symp., Upton, N.Y. (R. C. Fuller, Biology Dept., Brookhaven National Laboratory, Upton, L.I.)

16–20. American Soc. for Engineering Education, annual, Berkeley, Calif. (W. L. Collins, Univ. of Illinois, Urbana.)

16–20. Association of Official Seed Analysts, annual, Montreal, Quebec, Canada. (L. C. Shenberger, Seed Lab., Dept. of Agricultural Chemistry, Purdue Univ., Lafayette, Ind.)

16–20. Molecular Structure and Spectroscopy Symp., Columbus, Ohio. (R. A. Oetjen, Dept. of Physics and Astronomy, Ohio State Univ., Columbus 10.)

16–20. Pacific Div., AAAS, annual, Logan, Utah. (R. C. Miller, California Acad. of Sciences, Golden Gate Park, San Francisco 18.)

17–19. American Dairy Science Assoc., annual, Raleigh, N.C. (H. F. Judkins, 32 Ridgeway Circle, White Plains, N.Y.)

17–19. American Meteorological Soc., with Pacific Div., AAAS, Logan, Utah. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

18–20. Statistical Methods in Radio Wave Propagation, intern. symp., Los Angeles, Calif. (W. C. Hoffman, 3116 Engineering Bldg., Univ. of California, Los Angeles 24.)

18–21. College Physicists, 20th annual colloquium, Iowa City, Iowa. (J. A. Van Allen, Dept. of Physics, State Univ. of Iowa, Iowa City.)

18–22. American College of Chest Physicians, annual, San Francisco, Calif. (M. Kornfeld, ACCP, 112 E. Chestnut St., Chicago 11, Ill.)

19–21. Endocrine Soc., 40th annual, San Francisco, Calif. (H. H. Turner, 1200 N. Walker St., Oklahoma City 3, Okla.)

19–21. Society of Nuclear Medicine, 5th annual, Los Angeles, Calif. (R. W. Lackey, 452 Metropolitan Bldg., Denver, Colo.)

19–25. Scandinavian-American Meteorological Meeting, Bergen, Norway. (K. C. Spengler, 3 Joy St., Boston, Mass.)

21–22. Society for Investigative Dermatology, annual, San Francisco, Calif. (H. Beerman, 255 S. 17 St., Philadelphia 3, Pa.)

22–25. American Soc. of Agricultural Engineers, 51st annual, Santa Barbara, Calif. (J. L. Butt, ASAE, St. Joseph, Mich.)

22–25. Medicinal Chemistry, 6th natl. symp., Madison, Wis. (E. Smissman, College of Pharmacy, Univ. of Wisconsin, Madison.)

22–27. American Inst. of Chemical Engineers, 50th anniversary, Philadelphia, Pa. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

22–27. American Soc. for Testing Materials, 61st annual, Boston, Mass. (F. F. Van Atta, ASTM, 1916 Race St., Philadelphia 3, Pa.)

23–24. Unstable Chemical Species Symp., Los Angeles, Calif. (Directorate of Advanced Studies, Air Force Office of Scientific Research, P. O. Box 2035-D, Pasadena, Calif.)

23–25. American Soc. of Heating and Air-Conditioning Engineers, semiannual, Minneapolis, Minn. (A. V. Hutchinson, ASHAE, 62 Worth St., New York 13.)

23–25. American Soc. of Refrigerating Engineers, annual, Minneapolis, Minn. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

23–27. American Soc. of Civil Engineers, Portland, Ore. (W. H. Wisely, ASCE, 33 W. 39 St., New York 18.)

23–28. Low Temperature Physics, 6th internatl. conf., Leiden, Netherlands. (J. van den Handel, Kamerlingh Onnes Laboratory, Leiden.)

24–26. Carcinogenesis: Mechanisms of Action, Ciba Foundation symp. (by invitation), London, England. (G. E. W. Wolstenholme, 41 Portland Pl., London, W.1.)

24–27. American Home Economics Assoc., annual, Philadelphia, Pa. (Miss M. Horton, AHEA, 1600 20 St., NW, Washington 9.)

25–28. American Assoc. of Physics Teachers, Boulder, Colo. (F. Verbrugge, School of Physics, Univ. of Minnesota, Minneapolis.)

25–1. International Soc. of Urology, 11th, Stockholm, Sweden. (G. Giertz, Karolinska Sjukhuset, Stockholm C.)

29–2. American Astronomical Soc., Madison, Wis. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

29–4. National Education Assoc., Cleveland, Ohio. (W. G. Carr, NEA, 1201 16 St., NW, Washington 6.)

30–5. High Energy Nuclear Physics Conf., annual (by invitation), Geneva, Switzerland. (CERN, Geneva 23.)

July

4–6. Astronomical League, Ithaca, N.Y. (Miss W. A. Cherup, 4 Klopfer St., Millvale, Pittsburgh 9, Pa.)

6–12. Cancer Cong., 7th intern., London, England. (H. F. Dorn, National Inst. of Health, Bethesda 14, Md.)

7–9. Exchange of Knowledge in a Divided World, Chicago, Ill. (H. W. Winger, Graduate Library School, Univ. of Chicago, Chicago 37).

7–11. Technical and Industrial Communications Inst., Fort Collins, Col. (Chairman, Dept. of English and Modern Languages, Colorado State Univ., Fort Collins.)

7–12. Nuclear Physics, intern. cong., IUPAP, Paris, France. (C.I.P.N., Institut du Radium, II, rue Pierre Curie, Paris 5e.)

8–11. Institute of the Aeronautical Sciences, summer, Los Angeles, Calif. (S. P. Johnston, IAS, 2 E. 64 St., New York 21.)

9–15. Zoological Nomenclature Colloquium, London, England. (F. Hemming, 28 Park Village East, Regent's Park, London, N.W.1.)

10–14. Research Methods in Soil Zoology, colloquium, Harpenden, Hertfordshire, England. (P. W. Murphy, Rothamsted Experimental Station, Harpenden.)

15–22. Association Française pour l'Avancement des Sciences, 77th cong., Namur, Belgium. (AFAS, 28, rue Serpente, Paris VIe, France.)

15–23. Educational Treatment of Deafness, Intern. cong., Manchester, England. (A. W. G. Ewing, Dept. of Education of the Deaf, Univ. of Manchester, Manchester 13.)

16–23. Zoology, 15th Intern. cong., London, England. (H. R. Hewer, c/o British Museum of Natural History, Cromwell Road, London, S.W.7.)

21–24. High Polymer Conf., intern., Nottingham, England. (Conference Secretariat, Dept. of Scientific and Industrial Research, Charles House, 5–11, Regent St., London, S.W.1.)

24–25. Computers and Data Processing, 5th annual symp., Denver, Col. (Electronics Div., Denver Research Inst., Univ. of Denver, Denver 10.)

25–29. Chromatic Discrimination in Animals and Man, ICSU symp., Paris, France. (H. Pieron, Collège de France, Place Marcelin-Berthelot, Paris 5e.)

Equipment

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■ WALK-IN ROOMS for plant growing provide variable temperature, humidity, and illumination. Standard sizes available are 4 by 4, 4 by 6, and 4 by 8 ft; all are 7 ft high. Interiors are finished in white baked-on enamel. Ceilings are equipped with special fluorescent lights simulating sunshine. Rooms may be operated below and above ambient temperature; they can be supplied with or without shelving. (Labline Inc., Dept. 39)

■ VOLTAGE-TO-DIGITAL CONVERTER converts input voltage to four binary-coded decimal digits with accuracy of ±0.05 percent one-half of the least significant binary digit. More than 3700 such conversions may be completed in 1 sec. Standard full-scale input ranges are ±10, ±100, and ±1000. Range switching is accomplished by application of an external trigger pulse. Output can be read by means of neon indicators and is available in the form of parallel voltage levels that are either high or low in accordance with the binary code. (Epsco Inc., Dept. 41)

■ CAPACITANCE INDICATOR is a self-balancing instrument that automatically indicates capacitance and dissipation factor in an average time of 7 sec. Capacitance range is 100 pf to 1.1 μf in four ranges, and dissipation factor is measured from 0 to 16 percent in three ranges. Range switching is automatic. The unit is available with digital readout or with analog voltage read-out. (Barnes Development Co., Dept. 42)

■ DIRECT-COUPLED FILTER is a dual unit designed to provide high-pass and low-pass filtering with d-c response. The two units are interchangeable and can be interconnected. The individual section cutoff frequency is continuously adjustable over five decades from 0.2 to 20,000 cy/sec. Alternative d-c blocking inputs are provided. (Spectrum Instruments Inc., Dept. 45)

■ AMMONIA-TYPE MASER OSCILLATOR is a portable, sealed unit that generates a K-band frequency with stability better than 1 part in 10^9. The instrument, a molecular-beam oscillator, can operate for more than 500 hours without breaking the vacuum seal. Replacement parts permit an additional 500 hr of operation. Shelf life is a minimum of 1 yr. The oscillator weighs 20 lb and occupies a volume of 1 ft^3. (Polytechnic Research & Development Co., Inc., Dept. 62)

■ LIQUEFIED-GAS LEVEL-REGULATOR maintains level of liquid within 0.25 in. in cold finger or freezing bath of any apparatus. The device is based on an air thermometer made of glass. Rise of temperature of the thermometer actuates a mercury seal in a breather tube of the source of liquefied gas. The resulting build-up of pressure causes liquid to flow to raise the controlled level. (Fisher Scientific Co., Dept. 65)

■ PAPER-CHROMATOGRAM SCANNER handles either strip or two-dimensional chromatograms automatically, detecting beta-gamma emitting isotopes such as C^{14}, S^{35}, and P^{36}, and, when operated as a proportional counter, alpha radiation. The instrument incorporates a detector, scaler, recorder, and scanning mechanism. A variety of traverse distances and scanning rates are provided. Once started, the unit completes the scanning operation and turns itself off. (Nuclear Measurements Corp., Dept. 50)

■ ELECTRICALLY ACTUATED PRINTER is capable of a maximum of 150 printing operations per minute with simultaneous entry of up to 14 digits. Up to 136 characters and spaces may be printed on a single line. The carriage can be programed to tabulate fixed or variable distances after print-out. An accompanying control unit that provides proper pulse duration is capable of operating the printer over a source-voltage range of 100 to 125 v. (Monroe Calculating Machine Co., Inc., Dept. 56)

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■ ENVIRONMENT TEST CHAMBER comprises a 27-ft^3 altitude simulation chamber nested within a 53 ft^3 temperature-control chamber. The altitude chamber, which simulates altitudes to 200,000 ft, may be lifted out and used independently. The temperature chamber is usable in the range from $-100°$ to $+400°$F. (Mantec Inc., Dept. 58)

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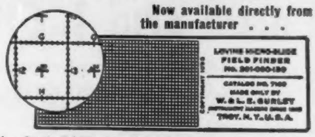

Ask for Bull. LMS, **W. & L. E. Gurley, Troy, N.Y.**

SUPPLIES AND EQUIPMENT

WHITE MICE

Hamsters, Guinea Pigs and Rats

J. E. STOCKER Box 4 Ramsey, N.J.

BENZOIC ACID-7-C^{14}

Write for a new catalog

Isotope Chemical Co.

1952 W. Irving Park Rd. Chicago 13, Ill.

16 May 1958

Readers' Service
Information Requisition

Use this easy self-mailer to obtain further information

It's simple: Mark — Clip — Fold — Mail

This coupon is for your convenience—to facilitate your requests for further information about advertised products and items in Equipment.

From:

Name .... **Position** ....

Company ....

Street ....

City .... **Zone** .... **State** ....
(Please print or type)

Mark, clip coupon — FOLD HERE along this line — stamp, mail

3¢
STAMP

To:

Readers' Service
SCIENCE MAGAZINE
Room 740
11 West 42 Street
New York 36, New York

Fasten Here Only
Staple, Tape, Glue

16 May 1958

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Information Requisition

Use this easy self-mailer to obtain further information about items or literature from the Equipment section as well as from advertised products.

EQUIPMENT

Circle below desired number corresponding to:

39	41	42	45	49	50	52
56	58	59	61	62	65	

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Check page number in list below of advertiser from whom you would like more information. If more than one item appears in ad, letters (A, B, C) are used to indicate particular items available in order of appearance in advertisement. Where more than one ad appears on page, **"U" indicates upper ad, "L" lower ad, "I" inside ad, "M" middle ad,** and **"O" outside ad.** Advertisements in Personnel Placement and Market Place are not keyed. A multiplicity of items is indicated by *. Readers are requested to specify on this coupon the particular item in which they are interested; otherwise, the request cannot be processed.

□ 1138, A	□ 1138, B	□ 1139	□ 1140*	□ 1141
□ 1142*	□ 1143, A	□ 1143, B	□ 1143, C	□ 1144
□ 1146	□ 1186	□ 1187	□ 1188	□ 1189, UI
□ 1189, UO	□ 1189, L (A)	□ 1189, L (B)	□ 1190, UO	□ 1190, LO
□ 1191	□ 1193, UI	□ 1193, LI	□ 1193, O	□ 1194
□ 1195	□ 1196, UO	□ 1196, UI	□ 1199, UI	□ 1199, UO
□ 1199, L	□ 1200			